# ABSTRACTS

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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.

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| 1056 | January 13–16, 2010 | San Francisco, CA | September 22 | Vol 31, No. 1 |
| 1057 | March 27–28, 2010 | Lexington, KY | February 2 | Vol 31, No. 2 |
| 1058 | April 10–11, 2010 | St. Paul, MN | February 16 | Vol 31, No. 2 |
| 1059 | April 17–18, 2010 | Albuquerque, NM | February 23 | Vol 31, No. 3 |
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| 1061 | June 2–5, 2010 | Berkeley, CA | April 13 | Vol 31, No. 3 |
| 1062 | October 2–3, 2010 | Syracuse, NY | August 10 | Vol 31, No. 4 |
| 1063 | October 9–10, 2010 | Los Angeles, CA | August 17 | Vol 31, No. 4 |
| 1064 | October 29–31, 2010 | Notre Dame, IN | September 7 | Vol 31, No. 4 |
| 1065 | November 6–7, 2010 | Richmond, VA | September 14 | Vol 31, No. 4 |

## SAN FRANCISCO, CA, January 13–16, 2010

Abstracts of the 1056th Meeting.

# *00 ► General*

1056-00-40 **Steven Strogatz*** (shs7@cornell.edu), 212 Kimball Hall, Ithaca, NY 14853. *The calculus of friendship.*

In this public lecture, Professor Strogatz tells the story of his extraordinary connection with his high school calculus teacher, Mr. Don Joffray, as chronicled through more than thirty years of letters between them. What makes their relationship unique is that it is based almost entirely on a shared love of calculus. For them, calculus is more than a branch of mathematics; it is a game they love playing together, a constant when all else is in flux. The teacher goes from the prime of his career to retirement, competes in whitewater kayaking at the international level, and loses a son. The student matures from high school math geek to college professor, suffers the sudden death of a parent, and blunders into a marriage destined to fail. Yet through it all they take refuge in the haven of calculus. . . until a day comes when calculus is no longer enough.

Like calculus itself, this lecture is an exploration of change. It's about the transformation that takes place in a student's heart, as he and his teacher reverse roles, as they age, as they are buffeted by life itself. It is intended for a general audience, and especially anyone whose life has been changed by a mentor. (It also includes some nifty calculus problems.)
(Received July 08, 2009)

1056-00-106 **Nick C Fedewa*** (fedew1n@cmich.edu), Department Of Mathematics, Central Michigan University, Mount Pleasant, MI 48859, **Emily E Krause** (kraus1ee@cmich.edu), Department of Mathematics, Central Michigan University, Mount Pleasant, MI 48859, **Alexandra M Sisson** (sisso1am@cmich.edu), Department of Mathematics, Central Michigan University, Mount Pleasant, MI 48859, and **James R Angelos** (james.angelos@cmich.edu), Department of Mathematics, Central Michigan University, Mount Pleasant, MI 48859. *The Spread of A Rumor.* Preliminary report.

The spread of a rumor can be modeled as a classroom with n students and, on day one, a person is told a rumor. On day two, this person draws a number at random. If they draw their own number, the rumor is not spread and the process is repeated the next day. However, if they choose any number besides their own, they tell that person. Now two people would now know the rumor and they would both choose numbers at random the next day. Just as before, they tell the people that correspond with the numbers they chose. This process continues until the entire population hears the rumor. This has been expanded to add in stiflers, people who know the rumor, but do not spread it. The rumor stops spreading when either there are no more ignorants or spreaders. There are three main models to this method, based upon how people transition to stiflers. Using sampling without replacement requires the use of the multivariate hypergeometric distribution (MHD). The differential equations are derived from expected values of a MHD for the first expected value. From there, a conditional MHD was used for the remaining two expected values. These results were then used to analyze each model. (Received July 27, 2009)

1056-00-160 **Jane W Hartsfield*** (awesome1jh@gmail.com), 4200 Cathedral Ave., NW, Unit #910, Washington, DC 20016. *Why should humanities majors have all the fun?*

Why are there almost no study abroad opportunities for math majors? What type of study abroad would make sense? How do I plan it? What things should I look out for? What course materials do I use? I will address these questions and talk about the logistics used for a successful study abroad to Greece and Turkey that I designed at UNC-Asheville. (Received August 08, 2009)

1056-00-164 **Chelsea M Walton*** (notlaw@umich.edu), 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109. *Point Parameter Rings.*

In the late 1980s, the field of Noncommutative Projective Algebraic Geometry emerged through several individuals' aim to classify certain noncommutative graded algebras with use of geometric data. We first discuss techniques of Artin-Tate-van den Bergh that describe the ring-theoretic and homological behavior of these structures. In particular, the roles of Sklyanin algebras and twisted homogeneous coordinate rings are highlighted.

Moreover we introduce a generalized twisted homogeneous coordinate ring P associated to a degenerate version of the three-dimensional Sklyanin algebra. The surprising geometry of these algebras yields an analogue to a result of ATV, namely that P is a factor of the corresponding degenerate Sklyanin algebra. (Received August 10, 2009)

1056-00-318 **Ashley N Moses*** (mosesan@slu.edu), Saint Louis University, Department of Mathematics, 220 N. Grand Blvd., St. Louis, MO 63103. *Linear Dependence of Translates.* Preliminary report.

Edgar and Rosenblatt have proven that any nonzero function $f \in L^p(\mathbb{R}^n)$ with $p < 2n/(n-1)$ has linearly independent translates. More specifically, it has been shown that there exists a nonzero function $f \in L^p(\mathbb{R}^2)$, nonzero constants $c_k$, and distinct elements $g_k \in \mathbb{R}^2$, $k = 1...K$, such that $\sum_{k=1}^{K} c_k f(x - g_k) = 0$ only for $p \leq 4$. This talk will show that given any even number k, there exists a function $f \in L^p(\mathbb{R}^2)$ such that a multiple of $f$ can be written as the sum of k distinct translations of itself. (Received August 28, 2009)

1056-00-359 **John R Meuser*** (jmeuser@gmail.com), 15 Toddington Terrace, St.Louis, MO 63128. *m-Refinably Extendable Functions.* Preliminary report.

A function is $m$-refinable if it can be written as a linear combination of its $m$-dilates and integer translates. The coefficients of this linear combination form a sequence called the *refinement sequence*. Let $f : [0, N) \to \mathbb{R}$ and pick a sequence of real numbers $\{c_i\}_{i=0}^{N}$ so that $c_0, c_N \neq 0$. Then a unique function $\tilde{f} : \mathbb{R} \to \mathbb{R}$ can be constructed so that $\tilde{f}|_{[0,N)} = f$ and $\tilde{f}$ is refinable with refinement sequence $\{c_i\}_{i=0}^{N}$. The construction of $\tilde{f}$ suggests a method for characterizing all compactly supported $m$-refinable functions. (Received September 01, 2009)

1056-00-435 **Charles Dunn**, **David Morawski*** (dmorawski@berkeley.edu) and **Jennifer Nordstrom**. *The game chromatic index of trees.*

The $(r, d)$-relaxed edge-coloring game is a two-player game played on the edge set of a graph $G$ with $r$ colors. The players alternate coloring the uncolored edges of $G$ such that every colored edge $e$ is adjacent to at most $d$ edges with the same color as $e$. The first player begins the game and wins if the graph is eventually colored with $r$ colors. Otherwise, there is some edge that cannot be colored and the second player wins. We consider this game on trees and show that, for any tree $T$ and $k \in [\Delta(T) - 1]$, the first player has a winning strategy when $r = \Delta(T) - k$ and $d \geq 2k + 2$. (Received September 07, 2009)

1056-00-511 **Daniel D Sheng*** (danieldsheng@gmail.com), Senior Class, Westwood High School, 12400 Mellow Meadow Drive, Austin, TX 78750, and **Edwin Oxford** (Ed_Oxford@baylor.edu), Department of Mathematics, Baylor University, One Bear Place, Waco, TX 76798-7328. *Remarks on the Apportionment of the U. S. House of Representatives.* Preliminary report.

In this presentation we will discuss apportionment as related to the United States House of Representatives. A number of methods will be discussed, including the traditional methods. Procedures for calculating the apportionments given by some divisor methods will be presented, with a special focus on the working rules of E. V. Huntington. In addition, data from the decennial census are used to give simple indicators of bias. Some ideas for continued research will be mentioned. (Received September 10, 2009)

1056-00-626 **Joseph M Burdis*** (jmburdis@ncsu.edu) and **Irina A Kogan**. *begincenter Equivalence of Curves Under Generalized Weak Perspective Projection. endcenter.*

A generalized weak perspective projection is a parallel projection from the 3-dimensional space to a plane. The degrees of freedom include the direction of the parallel projection and the coordinate system on the plane. We provide a computational algorithm for deciding whether a given curve in 3-dimensional space and a given planar curve are related by a generalized weak perspective projection. A variation of this algorithm is applicable for deciding whether a given finite set of ordered points in 3-dimensional space and a given finite set of ordered points on a plane are related by a generalized weak perspective projection. The latter problem was solved by a different method by Arnold, Stiller, and Sturtz in 2006. The problem is motivated by applications in computer image recognition. (Received September 14, 2009)

1056-00-1037 **Amit Singer*** (amits@math.princeton.edu), Department of Mathematics and PACM, Fine Hall, Washington Road, Princeton, NJ 08544-1000. *Spectral Methods and Semidefinite Programming for Cryo-EM, NMR Spectroscopy, Low-Rank Matrix Completion and Computer Vision.*

We will show that the mathematical problem in each of the applications listed below can be formulated as finding the unknown group elements from noisy partial observations of ratios between the group elements. Unlike the popular $\ell_2$ or $\ell_1$ minimization techniques, our spectral and semidefinite programming relaxations to recover the group elements perform incredibly well in the presence of a large number of outliers.

Applications include:

- Cryo Electron Microscopy for protein structuring: reconstructing the three-dimensional structure of a molecule from projection images taken at random unknown directions (unlike classical tomography, where imaging directions are known).
- NMR spectroscopy for protein structuring and localization of sensor networks from noisy distance measurements.
- Structure from motion in computer vision.
- Low rank matrix completion: filling in the missing entries of a low-rank matrix when a large portion of the observed entries are outliers.

Joint work with Ronen Basri (Weizmann), Ronald Coifman (Yale), Mihai Cucuringu (Princeton), Ronny Hadani (UT Austin), Yaron Lipman (Princeton), Yoel Shkolnisky (Tel Aviv) and Fred Sigworth (Yale). (Received September 20, 2009)

1056-00-1096 **Michael C. Sostarecz*** (msostarecz@monm.edu), 700 East Broadway, Monmouth, IL 61462. *GPS Tracking of a Roller Coaster.* Preliminary report.

In many calculus textbooks, a main example for motivating student interest in the relationship between position, velocity and acceleration is the roller coaster. Typically, these examples are a roller coaster only in the most idealized sense. In an attempt to obtain a more realistic point of view, students from Monmouth College acquired position data for the Six Flags St. Louis roller coaster "The Boss" using a Global Positioning System (GPS) device. This talk will discuss the ups and downs involved in the data collection and curve fitting from their roller coaster rides and how the data is being used in first semester calculus. (Received September 20, 2009)

1056-00-1171 **Andrew Lazowski*** (alazowski@wesleyan.edu), Department of Mathematics, Wesleyan University, Science tower 655, 256 Church Street, Middletown, CT 06459. *The Hausdorff dimension of limit sets of subgroups of Kleinian groups.*

The limit set of a Kleinian group is the "locus of chaotic behavior" of the Kleinian group's action on the Riemann sphere. The Hausdorff dimension of the limit set measures the complexity of the limit set. We describe some recent results in the study of the Hausdorff dimension of subgroups of a Kleinian group. (Received September 21, 2009)

1056-00-1188 **fatemeh emdad*** (faemdad@utmb.edu) and **michael kirby**. *Signal Fraction Analysis with Constraints and Extensions.*

In this paper we revisit the singular value decomposition (SVD, the generalized singular value decomposition (GSVD), and motivate the notion of row and column energy optimization problems for signal-to-signal ratios (SSR). We present Signal Fraction Analysis (SFA), a general tool for computing subspaces for decomposing data into potentially useful features. We show its connection to GSVD. We define the row-energy and column-energy optimization problems for SSR, derive the resulting GSV value problem and distinguish this setting from the standard SVD. We extend SFA by introducing novel constraints.

The subspace approach to signal processing consists of decomposing the data into parts that reveal the essential information, or structure, of interest. Standard subspace methods arising from the consideration of the data as a single set, such as the SVD, fail to characterize, or exploit, the distinction between the data sets. In this setting it is desirable to construct a single basis for the two data that simultaneously describes each and their differences. We extend SFA by introducing novel constraints and propose two new GSVD type problems for computing subspace representation. We conclude our work comparing the subspace representation for two different data sets. (Received September 21, 2009)

1056-00-1232 **Robert M. Sulman*** (rsulman@centralmethodist.edu), Central Methodist University, Fayette, MO 65248. *Disruption of Symmetry Creates New Symmetries.* Preliminary report.
The quadratic f(x)=ax$^2$+bx+c (a>0) has symmetry about a vertical line. When we divide f by g(x)=px$^2$+qx+r (p>0) the symmetry above is disrupted. However, new symmetries are created and they are examined in this talk. Specifically, the graph of h=f/g will always have a minimum value y = m and a maximum value y = M when disc(g) is negative and the axes of symmetry of f and g are different. If this is the case, then: (i) Mm=disc(f)/disc(g) (ii) Mm=$\beta$(f)/min(g), where $\beta$ is the horizontal asymptote of h and y=min(f),y=min(g) are the minimum values of f and g (occurring at each vertex). As a consequence of (ii) we see that if either graph(f) or graph(g) are translated horizontally (not to share axis of symmetry), the resulting rational function will have a minimum and maximum value whose product is Mm. That is, the product of extreme values is invariant under horizontal shifts of the numerator and denominator. A look at what this means geometrically and some concrete examples are given. This result is derived solely using methods of Pre-Calculus and is thus accessible to anyone with such background. (Received September 21, 2009)

1056-00-1370 **Thomas Matthews*** (tmnqb@mst.edu), Dept. of Mathematics and Statistics, 400 W. 12th Street, Rolla, MO 65409-0020, and **Dr. Martin J. Bohner**. *Probability on time scales.*
We establish generalized definitions, properties and applications in probability on time scales. Moreover examples for particular time scales will be presented. (Received September 21, 2009)

1056-00-1595 **Pam Arroway*** (pam_arroway@ncsu.edu), CB 8203, Raleigh, NC 27695, and **Ashley Swandby**. *Trends in Statistics PhD Graduates.*
The Annual Survey of the Mathematical Sciences collects information about departments in the mathematical sciences, their faculty and their students. The survey is jointly sponsored by the American Mathematical Society (AMS), the American Statistical Association (ASA), the Institute of Mathematical Statistics (IMS), the Society of Industrial and Applied Mathematics (SIAM) and the Mathematical Association of America (MAA). One segment of the survey gathers data on recent PhD graduates in the Mathematical Sciences. While the AMS publishes four useful reports on these data annually, further analysis of Statistics graduates is needed. Trends for Statistics graduates may look quite different than the Mathematical Sciences overall. Some places where striking differences can be seen is in the demographics of graduates and trends in the types of first jobs graduates accept. These differences may affect recruiting strategies for the profession and departments of Statistics, may be useful in hiring of faculty in Statistics, especially in Mathematics Departments, and may help inform the Statistics community about where Statistics graduates go. This presentation will summarize recent trends in statistics PhD graduates and compare them with those in Mathematical Sciences as a whole. (Received September 22, 2009)

1056-00-1674 **Michael Robert Yatauro*** (myatauro@stevens.edu), 806 Village Dr., Avenel, NJ 07001. *Best Monotone Degree Conditions for the Integrity and Tenacity of Graphs.*
It can sometimes be shown that all realizations of a degree sequence must have a certain property. A well-known theorem of V. Chvátal provides a "best monotone" degree condition for a graph to be hamiltonian. Similarly, it is possible to find a bound on a graph parameter so that in all realizations of a degree sequence the parameter will satisfy the given bound. Such a "best monotone" degree condition for graph connectivity was given by F. Boesch and J.A. Bondy. We will discuss what it means for a set of degree conditions to be best monotone. We then provide similar theorems for the integrity of a graph and the tenacity of a graph along with some examples. (Received September 22, 2009)

1056-00-1733 **Michael Booty*** (booty@njit.edu), Mathematical Sciences Department, New Jersey Institute of Technology, University Heights, Newark, NJ 07102. *Experiments from a Capstone Laboratory at New Jersey Institute of Technology.*

Sample experiments that have been used as part of a senior-level undergraduate Capstone course are presented, together with a brief outline of the associated mathematical models and the techniques that can be used to solve them. Also included are comments on what educational or other value both the instructor and the students believe was to be found in each case. (Received September 22, 2009)

1056-00-1867 **Solomon W Golomb*** (sgolomb@usc.edu), University of Southern California, 3740 McClintock Ave., EEB 504A, Los Angeles, CA 90089-2565. *Algebraic Constructions for Communication Sequences.*

Sequences are used to modulate signals in many applications involving digital communications, radar, sonar, synchronization and cryptography. The constructions of such sequences generally involve algebraic methods. Thus, the theory of maximum period linear shift register sequences as used in CDMA 3G cell phone systems is based on the properties of polynomials over finite fields. All the known systematic constructions for Costas arrays, used to generate frequency hopping patterns for radar and sonar that have ideal "thumb-tack" ambiguity functions, are based on properties of primitive elements in finite fields. This talk summarizes much of what has already been done, and delineates research areas with interesting unsolved algebraic problems whose solutions would have useful applications. (Received September 22, 2009)

1056-00-1928 **Julius Heim*** (jshxvd@mst.edu), Deptartment of Mathematics and Statistics, 400 West 12th Street, Rolla, MO 65409-0020, and **Martin Bohner** (bohner@mst.edu), Deptartment of Mathematics and Statistics, 400 West 12th Street, Rolla, MO 65409-0020. *Linear and nonlinear cobweb models on time scales.*

In this work we discuss cobweb models on time scales. In particular we present a linear cobweb model described by a linear first-order dynamic equation that we later extend in the sense that we additionally consider the concept of normal prices. Furthermore we derive a second-order linear dynamic equation which represents a cobweb model and finally we take a nonlinear cobweb model into consideration. For all models we establish stability criteria and give examples for particular time scales. (Received September 22, 2009)

1056-00-2004 **Radu S Roiban***, 104 Davey Lab #110, Department of Physics, Pennsylvania State University, University Park, PA 16802. *Integrable models and the gauge/string duality.*

The appearance of integrable models in the context of the gauge/string duality is reviewed. We will summarize the recent progress and emphasize the open problems. (Received September 22, 2009)

# *01 ► History and biography*

1056-01-56 **Michel Pierre Serfati*** (serfati@math.jussieu.fr), IREM-Université Paris VII, Case courrier 7018, 2 place Jussieu, 75005 PARIS, France. *Descartes, Van Schooten, and algebraic extensions of fields.*

This talk is devoted to a few lines of a letter (dated 1649, April 9 th) of Descartes, addressed to Van Schooten. It contains an early occurrence in the history of an algebraic extension of a field. One will make a reconstruction of the cartesian method, which makes an extensive use of the procedure of indeterminate coefficients introduced for the first time by Descartes in 1637 in book II of the Geometry (in the context of finding tangents to an algebraic curve). Descartes' letter directly involved some specific algebraic extension of degree 9 of the field Q of the rational numbers. One will point out then the subsequent modern development of the structure of such field extensions, in particular in Dedekind's work (1871). (Received July 18, 2009)

1056-01-254 **Tom Archibald*** (tarchi@sfu.ca), Dept of Mathematics, Simon Fraser University, Burnaby, BC V5A1S6, Canada. *Maxwell, Poincaré and the Rings of Saturn.* Preliminary report.

Poincaré's interest in the equilibrium shape of rotating fluids under gravitation probably dated to his early studies of celestial mechanics, with significant discoveries of bifurcation points in the Jacobian series of equilibrium figures published in 1885. This led him to a conjecture that the bifurcations associated with the sequence of zonal harmonics led to systems of a planet with increasingly many moons. This conjecture was, in Chadrasekhar's words, "so intoxicating that those who followed Poincaré were not able to recover from its pursuit." Be that as it may, this interest motivated a course at the Sorbonne in 1900, and the culmination of this course was a discussion of the rings of Saturn. Basing his discussion on work of both Kovalevskaya and Maxwell, he argued that the rings could not be solid or liquid. In this paper we give an outline of these developments, some reasons why the question was considered important, and what such issues have to do with the prestige of mathematics around 1900. (Received August 20, 2009)

1056-01-273 **June Barrow-Green*** (J.E.Barrow-Green@open.ac.uk), Faculty of Mathematics, The Open University, Walton Hall, Milton Keynes, MK7 6AA, England. *From cascades to calculus: episodes in the history of Rolle's theorem.*

Rolle's Theorem is an important result familiar to anyone who has moved just beyond elementary calculus to the beginnings of analysis. But when Michel Rolle first stated his theorem in 1690, it appeared not in the context of the calculus but of equation solving. In this talk I shall describe some episodes from the theorem's journey out of algebra and into analysis. (Received August 24, 2009)

1056-01-278 **David R Bellhouse*** (bellhouse@stats.uwo.ca), Dept. of Statistical and Actuarial Sciences, Western Science Centre, University of Western Ontario, London, Ontario N6A 5B7, Canada. *The Genesis of Generating Functions in Abraham De Moivre's Work.*

In the Macclesfield Collection at Cambridge University Library, there are two manuscripts of identical material entitled "Combinations", one a rough copy and the other a copy in a very fine hand. The central result given in the manuscripts is a generating function used to find the number of outcomes in the sum of the faces that show in the throw of several dice. The same generating function finds its way into print in Abraham De Moivre's *Miscellanea Analytica* published in 1730. It is argued that the results in the manuscript are due to De Moivre and that they predate De Moivre's first work on probability, *De Mensura Sortis*. (Received August 24, 2009)

1056-01-304 **Tinne Hoff Kjeldsen*** (thk@ruc.dk), IMFUFA, NSM, bygning 27, Roskilde University, Universitetsvej 1, Post Box 260, 4000 Roskilde, Denmark. *From idea to mathematical object: Herman Minkowski's introduction of general convex sets.*

In this talk it will be discussed how the general concept of a convex body emerged and took form in Minkowski's work at the turn of the 20th century. The development of the idea of a convex body is followed through shifts in focus of research in parts of Minkowski's work. These shifts are identified by analysing which objects Minkowski studied, and which methods he used in the process of knowledge production. In particular, it will be illustrated how Minkowski used geometry to investigate the minimum problem for positive definite quadratic forms and then turned towards a study of the geometrical method itself, which then became the object under investigation. This turned out to be a very fruitful shift in focus from which a new theory, geometry of numbers, emerged along with the introduction of new mathematical objects, the general convex set being one of them. (Received August 27, 2009)

1056-01-306 **Donald Babbitt*** (dgbabbitt@sbcglobal.net), 484 E,. California Bl.-#15, Pasadena, CA , and **Judith Goodstein**. *Federigo Enriques' Obsession: A Tale from Italian Algebraic Geometry.* Preliminary report.

The talk reconstructs the historical context for a plaintive letter from Federigo Enriques to Beniamino Segre in 1945, near the end of Enriques' life. In 1904, Enriques published a paper claiming to give an algebro-geometric proof of a rather technical theorem that became an essential ingredient in the proof of one of the beautiful theorems of algebraic geometry in the early 20th century. Enriques' "proof" turned out to be flawed, and in 1921 Francesco Severi took pleasure in pointing this out. Enriques took offense, and they essentially stopped speaking to each other. For Enriques the quest for a algebro-geometric proof turned into an obsession. Although Henri Poincare' gave an independent transcendental proof for Enriques' "Theorem" in 1910, a half-century would pass before the French mathematician Alexander Grothendieck, in 1961, succeeded in obtaining an algebro-geometric proof of the 1904 Enriques theorem. In his 1945 letter to Segre, Enriques complains about the lack of an algebro-geometric proof of his "Theorem" and suggests that a proof he proposed in a later (1938) paper, using higher-order differentials (nilpotent objects), might work. He was essentially right. (Received September 18, 2009)

1056-01-307 **Abdulalim Abdullah Shabazz*** (shabazza@gram.edu), Grambling State University, Dept of Mathematics and Computer Science, 403 Main Street, PO Box 4257, Grambling, LA 71245. *The Number Zero: Its Origin and Use.*

From the third millennium on, the Egyptians had already developed the decimal notation and used the number zero, indicated by the spaces they left where the zero would be placed today. This way of recording numbers appeared in China, India, Persia and Babylonia, and in general, in the Middle East, East, North, West and Central Africa. It appeared in Spain and Portugal during the eight and ninth centuries, and after the thirteenth century in the rest of Europe. Not only did the use of zero in the decimal place-value system make ease of representing numbers however large or small it made ease of calculations with numbers. (Received September 22, 2009)

1056-01-335 **William Dunham*** (wdunham@muhlenberg.edu), Department of Mathematics and CS, 2400 W. Chew Street, Allentown, PA 18104. *Newton's Proof of Heron's Formula.*

This talk examines a derivation of Heron's formula, courtesy of Isaac Newton. The result, of course, dates back to classical times, but in 1707 Newton published an algebraic proof quite different from Heron's original. In so doing, he noted that algebraic proofs of geometrical results "... so much depend on the various Positions and complex Relations of Lines, that they require some farther Invention and Artifice to bring them into Algebraick Terms." Such artifice he provided in a clever argument that, although entirely elementary, allowed Newton to revisit one of geometry's greatest theorems. (Received August 30, 2009)

1056-01-393 **Florin N Diacu*** (diacu@uvic.ca), P.O.Box 3060 STN CSC, Victoria, B.C. V8W 3R4. *The $n$-body problem in spaces of constant curvature.*

This talk traces the history of the $n$-body problem in spaces of constant curvature, which was initiated for $n = 2$ by Bolyai and Lobachevsky in the 1830s, and studied by many mathematicians, including Dirichlet, Schering, Lipschiyz, Killing, Liebmann, Schrödinger, and many others. (Received September 03, 2009)

1056-01-399 **Ricie Dimatatac Bulanhagui*** (rcdbulanhagui@yahoo.com), Alalum, San Pascual, Batangas, Philippines. *Ancient Numeral System And The Great Pyramid.* Preliminary report.

The Rhind Mathematical Papyrus is named after Alexander Henry Rhind, a Scottish antiquarian, who purchased the papyrus in 1858 in Luxor Egypt. Assuming the details of the Rhind of Papyrus is true. The exact dimensions of Great Pyramid can be computed. Using the measuring instruments like seked and old calculation method I rediscovered in old Babylonian Mathematics.

Ancient System Given: Height: 280 cubits Base: 440 Cubits Half of the base: 220 Cubits Solution: 280/220 = 1.272

English System Given: Height: 480.97 Feet Base: 756.2 Feet Half of the Base: 378.1 Feet Solution: 480.97/378.1 =1.272

Seked Used: 7/5.5 =1.272

The tangent in Ancient System and English System is approximately equal to 1.272 which is equal to ratio of the seked 7/5.5.

In our present time we don't use seked, cubit and palm in measurement. We use meter, inch, and feet. How can we calculate the dimensions? There is another method that they use to calculate the height and base of the Great Pyramid. This procedure can calculate the dimensions of the Great Pyramid without using seked. The numeral system I rediscovered can bring light to understand the ancient civilization cultures and abilities. (Received September 04, 2009)

1056-01-482 **Brenda Davison*** (bdavison@sfu.ca), Department of Mathematics, Simon Fraser University, 8888 University Drive, Burnaby, B.C. V7S1L6, Canada. *The Early Years of G.H. Hardy's career.*

G.H. Hardy entered Trinity College, Cambridge in 1896, was 4th wrangler in the Tripos examination of 1898 and was elected as a fellow of Trinity College in 1901. The first period of Hardy's career can be demarcated by his college election and by the beginning of his collaboration, in 1911, with J.E. Littlewood. During this time he wrote a textbook of enduring importance, established a reputation as an analyst with papers on series and integral convergence, wrote five papers on set theory, contributed to the educational times and wrote several book reviews. He also began to play a role in political and social issues via his membership in the Apostles and the London Mathematical Society, as well as through his work to abolish the Tripos examinations. I will discuss Hardy's mathematical work during this period, particularly the 5 set theory papers written between 1904 and 1910, and examine the correspondence between Hardy, Russell and Jourdain. In so doing, I will establish that Hardy was among the first British mathematicians to engage with the new concepts of number, point-sets and transfinite numbers recently developed on the continent. I also will argue that Hardy's social activism was an important part of what made him such a dominant figure in British mathematics. (Received September 09, 2009)

1056-01-494 **James J Tattersall*** (tat@providence.edu), Department of Mathematics, Providence College, Providence, RI 02918. *Joel E. Hendricks and the Analyst.* Preliminary report.

Before founding *The Analyst: A Journal of Pure and Applied Mathematics* in 1874, Joel E. Hendricks (1818-1893) worked as farmer and as a mill-wright. He also read and practiced medicine, surveyed regions of Colorado, helped found and taught in the Newville Academy in Indiana, and served as Provost Marshall for DeKalb, County, Indiana. In 1864, he migrated to Des Moines, Iowa where he served as county treasurer and began editing and publishing the bimonthly *Analyst*. Hendricks was a member of the subculture of self-educated promoters of mathematics that existed in late nineteenth century America. His journal was a significant contribution to the mathematical literature of the time. We focus on the contributions to the *Analyst* from other members of the subculture and highlight what distinguished it from other such publications. (Received September 10, 2009)

1056-01-548 **Byron E. Wall*** (bwall@yorku.ca), 218 Norman Bethune College, York University, 4700 Keele Street, Toronto, Ontario M3J 1P3, Canada. *Pinning Down Outliers: 19th Century Stabs at Exact Probabilities for Rare Events.* Preliminary report.

In the late 19th century, statistics emerged as a discipline from probability theory. Statistics made predictions of future events based upon the past frequency of such events under similar circumstances. When the events were commonplace aspects of human experience, such as average longevity for males in the population, a lot of data supported the predicted likelihood of the unknown, future event. But the less frequent the event in question, the smaller the sample of data on which one could make predictions. In some cases, there were no previous outcomes of the kind contemplated. Yet these too were assigned probabilities. The question is, on what basis was a probability assigned for such events? It would not be surprising to find out that many of the assigned probabilities were not based on data at all, but instead were extrapolations based upon dubious assumptions about the symmetry of vast unknowns in Nature. A more disturbing thought is that such irrational probability assignments may have become the norm and have entered standard statistical practices and are still with us today. This paper explores some of the relevant cases from that period. (Received September 11, 2009)

1056-01-625 **Amy Ackerberg-Hastings*** (aackerbe@verizon.net), 5908 Halsey Road, Rockville, MD 20851. *What is a Great Book? A Case Study of Legendre's Éléments de Géométrie (1794) and Playfair's Elements of Geometry (1795).*

Both *Éléments de Géométrie* and *Elements of Geometry* were wildly popular textbooks in their day and remain well known to mathematicians, educators, and historians. Since they were published so close together and were so influential, it is logical to juxtapose their content and their authors. Adrien-Marie Legendre of France and John Playfair of Scotland both enjoyed international reputations, although Legendre made more substantial contributions to pure and applied mathematics. Yet, both authors directed these particular works at students, although there is some evidence that they also had larger contributions in mind. This raises questions about how we assess the quality of a textbook and whether we measure research content or pedagogical approach. In a larger sense, who decides which works are great books in mathematics, and what are the criteria to achieve the status of a great book? This talk, therefore, seeks to extend the themes raised in the MAA Short Course, "Exploring the Great Books of Mathematics," and the MAA Contributed Papers Session, "Mathematical Texts: Famous, Infamous, and Influential." (Received September 14, 2009)

1056-01-692 **Andrew B Perry*** (perryand@yahoo.com). *French and English Influences On Early American Mathematics.*

Clearly England had a profound effect on the mathematics studied in America in the eighteenth century. Until 1800 or so, most American math books in use had been imported from England or at least written by English Authors. (It should be noted that early American mathematical activity consisted of study rather than research, in most cases at elementary levels.) In the first half of the nineteenth century, however, the tide turned. Americans, apparently inspired by the superior mathematical achievements as well as mathematical exposition of the French at that time, began to follow the French mathematically to a much greater extent. For example, the most prolific American textbook author in the nineteenth century, Charles Davies, borrowed heavily from French sources. We will examine the transition between the dominant English and dominant French influence through the examination of early American mathematical texts and comparison with French and English works. We will focus especially on texts authored between 1800 and 1850. (Received September 16, 2009)

1056-01-808 **Jesper Lützen*** (lutzen@math.ku.dk), Department of Mathematical Sciences, Universitetsparken 5, DK-2100 Copenhagen O, Denmark. *Why was Wantzel Overlooked for a Century? The Changing Importance of an Impossibility Result.*

The duplication of a cube and the trisection of an angle are two of the most famous geometric construction problems formulated in ancient Greece. In 1837 Pierre Wantzel (1814-1848) proved that the problems cannot be constructed by ruler and compass. Today he is credited for this contribution in all general treatises of the history of mathematics. However, his proof was hardly noticed by his contemporaries and during the following century his name was almost completely forgotten. In this talk I shall analyze the reasons for this neglect and argue that it was primarily due to the lack of importance attributed to such impossibility results at the time. (Received September 17, 2009)

1056-01-849 **Dan Kalman*** (kalman@american.edu), Department of Mathematics and Statistics, American University, 4400 Massachusetts Avenue NW, Washington, DC 200168050, and **Mark McKinzie**. *Euler, Dilog, and Zeta(2).*

The story of Euler's original evaluation of $\zeta(2)$ and subsequent rederivations is well known. Each derivation shows the familiar Euler genius for creative manipulation of series. In the modern context, it is tempting to attempt an evaluation of $\zeta(2)$ by more mundane means, by manipulating the series $f(z) = \sum z^k/k^2$. One progresses without difficulty to find $\zeta(2) = \int_0^1 -\frac{\ln(1-t)}{t}\,dt$. Evaluating this integral presents an obstacle, but success is possible if one is aware of some properties of the dilog function $\mathrm{Li}_2(z) = \int_0^z \frac{-\ln(1-t)}{t}\,dt$. Thus we obtain another derivation of the value of $\zeta(2)$. And who discovered the requisite properties? Euler!

Euler's initial work with $\mathrm{Li}_2$ predates the evaluation of $\zeta(2)$, appearing in the same 1730 paper where he estimates $\zeta(2)$ to 6 decimal places. The critical identity for the definite integral above appears in a paper dating to 1779. There Euler might easily have evaluated $\zeta(2)$, but instead takes the value as a known result. Did he realize that his results provided yet another path to $\zeta(2)$? Could he have failed to notice? We know what Euler knew, but when did he know it? This historical puzzle remains unsolved. (Received September 18, 2009)

1056-01-929 **James Evans*** (jcevans@pugetsound.edu), Program in Science, Technology, and Society, University of Puget Sound, 1500 North Warner St., Tacoma, WA 98115. *The Mathematics of the Antikythera Mechanism.*

The Antikythera mechanism is a gear-work astronomical calculating machine that was built in the second century B.C. Lost in a shipwreck around 80 B.C., it was recovered in 1901 as a result of the first successful underwater archaeological expedition ever completed. A century of research, including some intensely interesting new work in the last decade, has gradually disclosed the purpose and function of this ancient machine. In this talk, we shall examine the mathematical foundations, both Greek and Babylonian, of the Antikythera mechanism. In the process, we shall see some interesting connections among the arts of astronomy, geometry, arithmetic and mechanics. (Received September 18, 2009)

1056-01-937 **Mohammad Moazzam*** (mxmoazzam@salisbury.edu), Department of Mathematics and Comp. Sci., 1101 Camden Avenue, Salisbury, MD 21801. *Nasir-aldin Tusi: A True Scholare in Many Disciplines.* Preliminary report.

Nasir-aldin Tusi: A True Scholar in many Disciplines This talk will feature the contributions of a famous Persian scholar with contribtions in many fields including, but not limited to mathematics. In Persian he is known as Khojeh Nasir Tusi or Nasir-aldin Tusi, but he was known as Al-Tusi by westerners. The audience for this presentation will be able to gain cultural insights into the work of this famous scholar from a native/born Persian/American who can add cultural perspective to many of the results. This talk should be of interest to mathematics professors who like to include the history of mathematics into their teaching of mathematical topics. Undergraduate/graduate students might find this Persian scholar of interest for use in research projects for their individual areas of interest. (Received September 18, 2009)

1056-01-1027 **Charlotte K. Simmons*** (cksimmons@uco.edu), 100 N. University Drive, Box 129, Edmond, OK 73034, and **Jesse W. Byrne** (jbyrne@uco.edu), 100 N. University Drive, Box 129, Edmond, OK 73034. *Benjamin Gompertz: Pioneer of Actuarial Science.* Preliminary report.

In this talk, we investigate the contributions of actuarial pioneer Benjamin Gompertz, known for his capacity to sustain the complex computation required to generate "tables of lives and tables of stars," to the field of actuarial science. Gompertz is best known today for his Law of Mortality, an extremely powerful tool in the study of mortality and the creation of life tables for actuaries. The significance of this law will be examined. Additionally, we will discuss the contributions of friend and staunch supporter, Augustus De Morgan, to the field, both direct (via his own work) and indirect (via his defense of Gompertz during the Edmonds-Gompertz controversy). Because of De Morgan's efforts, Edmonds is "now remembered only for the disparagement of the work of a man of genius," while Gompertz is remembered "because his outstanding brilliance as a mathematician was equalled by his modesty and generosity." (Received September 20, 2009)

1056-01-1042 **David Peifer*** (dpeifer@unca.edu), Mathematics Department, UNC Asheville, Asheville, NC 28804. *Max Dehn.*

Max Dehn began his mathematics career in the early 1900's solving the third of Hilbert's famous problems. He went on to hold several prominent positions in German Universities. He wrote foundational works in Topology and Infinite Group Theory. He spent the final years of his career at Black Mountain College, a small experimental liberal arts college with an emphasis on the arts. He lived through some of the most turbulent times in our recent history. This talk will give a brief history of Dehn's life, an overview of his mathematical works, and finally a brief explanation of his influence on current work by mathematicians such as W. Thurston and M. Gromov. (Received September 20, 2009)

1056-01-1072 **Menolly Lysne*** (mlysne@alumni.sfu.ca), 8888 University Dr, Burnaby, B.C. V5A 1S6, Canada. *Understanding Early Laplacian Simplifications.* Preliminary report.

In 1772, Pierre Simon Laplace (1749-1827) wrote a memoir entitled "Sur le principe de la gravitation universelle et sur les inégalités séculaires des planètes qui en dépendent" (On the principle of universal gravitation and on the secular inequalities of the planets which depend on it). At one point in this memoir, Laplace arrives at a system of partial differential equations that he did not have methods to solve exactly. He dealt with this problem by developing a method of simplification in order to solve this system. In the following years, Laplace decided that this method could be used as a general method for simplifying complicated equations. This talk will investigate the method itself and the validity of Laplace calling this a general method. I will argue that while Laplace was able to obtain solid results using his method, it could not be considered general because it was not easily repeatable using Laplace's instructions. (Received September 20, 2009)

1056-01-1116 **Janet L Beery*** (janet_beery@redlands.edu). *"Ad Calculum Sinuum": Thomas Harriot's Sine Table Interpolation Formulas.*

In about two dozen scattered, undated manuscript sheets, each headed "Ad Calculum Sinuum," Thomas Harriot (1560-1621) developed finite difference interpolation methods specifically for sine tables. Harriot shared these methods with his friend, William Lower, sometime before Lower's untimely death in 1615. Although Harriot would present more general interpolation formulas in 1618 or later in his unpublished manuscript treatise, "De numeris triangularibus et inde de progressionibus arithmeticis: Magisteria magna", his work on sine table interpolation was an important part of his interpolation project. In particular, it illustrates very clearly how he generalized from interpolating three values to interpolating $n$ values between successive table entries. In this presentation, we show how Harriot developed and used finite difference interpolation formulas for sine tables. (Received September 21, 2009)

1056-01-1124 **Allan D. G. Olley*** (allan,olley@utoronto.ca), IHPST, Victoria College, University of Toronto, 91 Charles Street West, Toronto, Ontario M5S 1K7, Canada. *If Brute Force Does Not Work You Are Not Using Enough: the rise of Numerical Integration in 20th Century Astronomy.*

Numerical integration is often referred to as a brute force technique because of its simple iterative nature and the ability to increase precision by doing more calculations, for the same reason numerical integration is associated with the modern computer. However, the rise of numerical integration in astronomy begins earlier and this paper will attempt to trace some of the developments and their implications. Philip Cowell's use of numerical integration in the first decade of the $20^{\text{th}}$ century to calculate the return point of Halley's comet set the stage for more widespread adoption and in astronomy gave the method its name (Cowell's method). Even before the advent of the electronic computer developments with calculating machines played a role in the adoption of numerical integration. With the advent of fully automatic electronic computers numerical integration of orbits became more common and complex. Eventually the standard astronomical tables of planetary position would be calculated by numerical integration. Yet the slowness and partiality of the change over to numerical integration suggests the complex history of this simple technique. (Received September 21, 2009)

1056-01-1156 **Dirk Schlimm*** (dirk.schlimm@mcgill.ca), McGill University, Department of Philosophy, 855 Sherbrooke St. W., Montreal, QC H3A 2T7, Canada. *Pasch and Klein on intuition and proofs.*

This paper presents some aspects of the views on mathematics of Moritz Pasch (1843–1930) and Felix Klein (1849–1925). Both made significant contributions to the development of geometry and while both agreed that mathematics should ultimately be grounded empirically, they disagreed on the role that intuition plays in mathematical proofs. Pasch gave the first rigorous axiomatization of projective geometry (1882), which paved the way for Hilbert's groundbreaking 'Foundations of Geometry' (1899), and he also demanded that diagrams and other appeals to intuition should play no role in deductions. Klein, who proposed a unified treatment of geometries in his famous 'Erlangen Program' (1872), is well-known for being one of the most forceful proponents of the use of intuition and model-based reasoning in mathematics. What has not received any attention in the history and philosophy of mathematics so far, is the debate between Pasch and Klein: they discussed their views in their correspondence, and Klein discussed Pasch's position in his lectures (1890, 1893), which Pasch commented in 1912. Finally, Klein added some reconciliatory remarks in his Collected Works (1922). In the present paper this debate between Pasch and Klein is presented in the context of their research styles. (Received September 21, 2009)

1056-01-1184 **William F. Lindgren*** (william.lindgren@sru.edu) and **Thomas F. Banchoff** (Thomas_Banchoff@brown.edu). *A comparison of Edwin Abbott Abbott and Lewis Carroll.* Preliminary report.

We compare the lives and works Edwin Abbott Abbott and Lewis Carroll, two authors whose books have long been cherished by the mathematical community. Although these two men were alike in several significant ways, in many more ways they were completely different. For example, Abbott earned first class honors in the classics and second class honors in mathematics at Cambridge, while Carroll earned first class honors in mathematics and second class honors in the classics at Oxford. We conclude with a very brief comparison of the books for which they are best known. (Received September 21, 2009)

1056-01-1189 **Kim Plofker*** (kim_plofker@alumni.brown.edu), Department of Mathematics, Union College, 807 Union Street, Schenectady, NY 12308. *The various "Indian rules" in medieval and early modern Western mathematics.* Preliminary report.

Mathematics in Latin and other European languages before the twentieth century accumulated an intriguing collection of algorithms and concepts characterized as "Indian" or "Hindu", ranging from false-position rules to geometric methods in astronomy to a version of the quadratic formula. Western mathematics also indirectly assimilated several mathematical ideas from the Indian tradition without an "Indian" label, such as the decimal place-value numerals known as "Arabic". This talk explores the influence of various Indian methods and the image of the "sapientes Indi" or "learned ones of India" in pre-modern European mathematics. (Received September 21, 2009)

1056-01-1249 **Josipa G Petrunic*** (j.petrunic@ucl.ac.uk), Department of Science and Technology Studies, University College London, Gower Street, London, WC1E 6BT, England. *Mathematics as imperialism? The role of mathematicians in the political expansion of British mathematical practices.*

A series of government-led initiatives in Britain – all of which took the form of Royal Commissions exploring the status of university curricula across the country – changed the manner in which mathematics was taught, learned and practiced from the 1830s onwards. From the mid-1850s to the 1880s, a second series of government-led reforms married mathematical teaching to natural philosophic or, rather, "scientific," practices, especially with regards to experimentation in chemistry and dynamics (or "physics"). The political motives underpinning those reform efforts were imbued with conceptions of imperial greatness and patriotic expansion abroad. In this paper, I will demonstrate how the British government's educational reforms from the 1850s onwards were part of a grander imperial process that sought to situate British mathematics and scientific innovation at the center of an expanding global economy and polity. Mathematicians were not neutral actors in this process. The case study of Isaac Todhunter, a mathematician who developed a series of widely-used mathematical textbooks throughout the mid-century, and whose career spanned the reform periods mentioned above, demonstrates that mathematicians were political agents, whether they chose to be or not. (Received September 21, 2009)

1056-01-1331 **Laura Martini*** (lauramartinisiena@gmail.com), Via D. di Boninsegna, 2, 53100 Siena, Italy. *Building a Nation: The Evolution of a Mathematical Research Community from the Italian States to the Kingdom of Italy.*

This talk traces the revival of Italian mathematics in the second half of the nineteenth century in an institutional, historical, political, and mathematical context with a focus on the developments that occurred during the process of political unification. After surveying the state of mathematics in the first half of the century, it will examine the changes that took place after 1861: the reform of the Italian educational system, the establishment and reorganization of institutions for higher education, the development of scientific academies and societies, the foundation of specialized mathematical journals, and the efforts of a group of scholars who worked in political, educational, and mathematical venues in order to improve the state of mathematics in unified Italy. (Received September 21, 2009)

1056-01-1560 **Michael Nauenberg*** (michael@physics.ucsc.edu). *Curvature and symmetry in Newton's early computations of orbital dynamics.*

Curvature and symmetry in Newton's early computations of orbital dynamics (Received September 22, 2009)

1056-01-1572 **Ruediger Thiele*** (ruediger.thiele3@freenet.de), Hall, Germany. *Johann Bernoulli's lost lecture on differential calculus and its sequels.*

During his stay in Paris in 1691/92 the young Johann Bernoulli provoked sensation because he was able to employ the Leibnizian calculus. The French mathematician l'Hospital even asked for an introduction into the calculus and stipulated a cumbersome contract with Bernoulli, who gave l'Hospital the entire authorship of all later publications in this field. In 1696 l'Hospital published the well-known "Analyse" which became the most influential text-book at the time.

How much did l'Hospital take from Bernoulli's lectures? The question has been vigorously debated although it can be definitely answered by an inspection of Bernoulli's lecture notes and his correspondence with l'Hospital. (Received September 22, 2009)

1056-01-1596 **Sandro Caparrini*** (caparrini@libero.it), Inst. for the Hist. and Phil. of Sc. and Tech, Victoria College 316, 91 Charles St. W, Toronto, Ontario M5S 1K7, Canada. *Italian Mathematics and Mechanics Between the 18th and 19th Centuries.*

While Italy produced no mathematicians of first rank in the years between 1780 and 1820, there were several minor figures that deserve a closer study. Thus, for example, V. Brunacci and V. Caluso were concerned with the foundation of analysis, G. Frullani and G. Bidone wrote several remarkable papers on definite integrals, G. Giorgini developed a purely analytic theory of directed line segments similar to modern vector calculus. P. Paoli, G. F. Malfatti, P. Delanges and G. Fontana discussed some problems related to the first principles of statics. P. Ruffini's results in early group theory are well-known. Many interesting works were published in the Memorie di matematica e di fisica della Società Italiana delle Scienze, one of the earliest journals almost entirely devoted to research in mathematics. Mention must also be made of some encyclopaedic treatises. Paoli and Brunacci published respectively the Elementi d'algebra (3 vols, 1794-1804) and the Corso di matematica sublime (4 vols, 1804-08), texts that bear comparison with Lacroix's great Traité; G. Venturoli's Elementi di meccanica e d'idraulica (2 vols, 1806; translated into English in 1823) is a concise but rigorous introduction to mechanics. The aim of the present talk is to give a general overview of this period. (Received September 22, 2009)

1056-01-1734 **Maryam Vulis*** (mlv2007@earthlink.net), 67-67 Burns St, Apt. 4k, Forest Hills, NY 11375. *Teaching Mathematics at the 19th century Virginia Military Institute.* Preliminary report.

This presentation will discuss the history of teaching mathematics at Virginia Military Institute in the 19th Century, with focus on the faculty and the content of some mathematics courses. (Received September 22, 2009)

1056-01-1790 **Chris Christensen*** (christensen@nku.edu), Department of Mathematics and Statistics, Northern Kentucky University, Highland Heights, KY 41099. *Algebraic cryptology from an historical viewpoint.* Preliminary report.

Algebraic ideas are now commonly used for encryption and decryption. But algebraic ideas were less visible in cryptology prior to 1976 – the date of the Diffie-Hellman paper. We will consider some cases where – over the 2000 plus years of cryptological history – the germs of algebraic ideas can be noticed. (Received September 22, 2009)

1056-01-1860 **Mahmoud H Annaby*** (mannaby@qu.edu.qa), Dept Mathematics, Statistics & Physics, Qatar University, Doha, 2713, Qatar. *On Avicenna's Arithmetic.*

Unlike his great contributions in medicine and philosophy, it is believed that Avicenna's mathematical works have no originality and that his contributions are limited to an editing of Euclid's Elements and transforming Nicomachus' Introduction to Arithmetic, in addition to the scattered mathematics in his books on logic, music and astronomy. We aim in this lecture to introduce Avicenna as one of the muslim mathematicians through studying the first essay of his book, The Arithmetic. We study this essay extensively and analyze its mathematical contents, especially arithmetical sequences, perfect, abundant and deficient numbers as well as amicable pairs. We also compare Avicenna's results with the works of other muslim mathematicians, like Al–Bagdadi, Al–Farisi and Al–Kashi. (Received September 22, 2009)

1056-01-1877 **Ivor O. Grattan-Guinness*** (eb7io6gg@waitrose.com), 43 St Leonard's Road, Bengeo, Hertford, SG14 3JW, England. *D company: the rise and fall of differential operator theory in Britain, 1810s-1870s.*

In operator calculus $D = d/dx$, positive powers of D denote orders of differentiation, and negative powers signal integration. This algebra has largely French origins in the late 18th century, growing especially out of work of (the Italian) Lagrange; but the French largely dropped it after criticisms by Cauchy in the 1820s. However, it had already become part of the British attachment to algebras of various kinds. Functional equations were another new algebra of French background and British fascination. After some attention was paid to both algebras from Charles Babbage and John Herschel in the 1810s and 1820s, the British took up operators again in the late 1830s. Duncan Gregory was an important pioneer, George Boole became the leading practitioner, and around a score of others took part up to W. H. L. Russell from the late 1850s onwards, after whom interest fell away markedly. Throughout some focus fell upon solving four differential equations, Riccati's and three due to Laplace. Some of the results went into British textbooks on the calculus and differential equations of this period. In this article I summarise its history, including a discussion of reasons for the near monopoly of study among English and Irish mathematicians, and the causes of the fadeaway. (Received September 22, 2009)

# 03 ► Mathematical logic and foundations

1056-03-69 **Fernando J. Ferreira*** (ferferr@cii.fc.ul.pt), Universidade de Lisboa, Dep de Matemática, Faculdade de Ciências, Campo Grande, Ed. C6, Piso 2, P-1749-016 Lisboa, Portugal. *Bar-recursive interpretations of classical analysis.*

Following the work of K. Gödel published in 1958, C. Spector gave in 1962 a remarkable characterization of the provably recursive functionals of full second-order arithmetic (a.k.a. analysis). Spector's interpretation relies on a form of well-founded recursion known as bar-recursion. Spector's interpretation is rather indirect, via the negative translation. We re-prove Spector's result avoiding the passage through intuitionistic logic, relying instead on the very simple direct interpretation of Peano arithmetic given by J. Shoenfield in 1967.

The bounded functional interpretation was introduced in 2005 by P. Oliva and the present author. In its version for classical arithmetic, it is an interpretation which "injects" some non set-theoretical uniformities into Peano arithmetic. Nevertheless, due to its Soundness Theorem, the interpretation is able to extract correct uniform bounds from certain theorems of mathematics (and this opens the way to possible contributions to Proof Mining).

We recently showed that the bounded functional interpretation is compatible (via bar-recursive functionals) with full numerical comprehension.

The above reported work is in collaboration with P. Engrácia. (Received September 15, 2009)

1056-03-71 **Joseph S. Miller*** (jmiller@math.wisc.edu), University of Wisconsin-Madison, Department of Mathematics, 480 Lincoln Drive, Madison,, WI 53706-1388. *Randomness and computational strength.*

One of the themes that has emerged in the study of effective randomness is that there is a negative correlation between randomness and computability-theoretic strength. Not only are more random reals less useful as oracles, but assuming that a random real is computationally weak implies a greater degree of randomness. We will explore the evidence for these assertions and look at some of the reasons why this inverse relationship should not be entirely surprising. As part of understanding this pattern, we will consider what it means for one real to be "more random" than another. (Received September 15, 2009)

1056-03-72 **Chris Miller*** (miller@math.ohio-state.edu), Ohio State University, Department of Mathematics, 231 West 18th Avenue, Columbus, OH 43210. *Expansions of o-minimal structures by trajectories of definable vector fields.*

An expansion of the real field is said to be o-minimal if every definable set has finitely many connected components. Such structures are a natural setting for studying "tame" objects of real analytic geometry such as nonoscillatory trajectories of real analytic planar vector fields. More generally, o-minimality is preserved under expanding by nonoscillatory trajectories of definable planar vector fields. But what happens when o-minimality is not preserved? We see in some cases the best behavior that we could reasonably hope for, while in some others the worst possible, and we do not know at present of any other outcomes. I will make all this precise in a survey of the current state of the art. (Received September 14, 2009)

1056-03-73 **Stevo Todorcevic*** (stevo@math.jussieu.fr), University of Toronto, Department of Mathematics, Toronto, ON M5S 2E4, Canada. *Tukey Reducibility as a Setup for Classifying Mathematical Structures.*

This will be an overview of recent advances on the Tukey classification program of mathematical structures such as graphs, partial orders, ultrafilters, etc. We will also expose some possible lines of further research and some open problems. (Received September 15, 2009)

1056-03-74 **Slawomir J. Solecki*** (ssolecki@math.uiuc.edu), University of Illinois, Department of Mathematics, 1409 W. Green St., Urbana, IL 61801. *Ramsey theory for finite structures.*

I will present a self-dual Ramsey theory for structures equipped not only with relations, but also with functions. These results expand and build on the work of Ramsey, Nesetril, Rodl, Abramson and Harrington on the direct relational theory and of Graham, Rothschild and Promel on the dual relational theory. (Received September 16, 2009)

1056-03-75 **John Harrison*** (johnh@ichips.intel.com), Intel Corporation, JF1-13, 2111 NE 25th Avenue, Hillsboro, OR 97124. *Decidability and Undecidability in Theories of Real Vector Spaces.*

It's natural to formulate theories of real vector spaces using a 2-sorted first-order language with a sort for the scalars and a sort for the vectors. Introduction of coordinates reduces the theory of a vector space of a specific finite dimension to the first-order theory of the real numbers, known to be decidable since Tarski. Experience in the actual formalization of mathematics motivates an investigation into decision problems for various more general 2-sorted first-order theories of vector spaces, with or without with an inner product, norm, assumption of completeness, or restriction on dimension.

Solovay, Arthan and the speaker have carried out a systematic study of decidability for such theories. The theories of real vector spaces, inner product spaces, and Hilbert spaces turn out to be decidable and to admit quantifier elimination in a slightly expanded language. However, similar theories of normed spaces, Banach spaces and metric spaces are not even arithmetical: the theory of 2-dimensional Banach spaces, for example, has the same many-one degree as the set of truths of second-order arithmetic. However, by restricting quantifier alternations, we can arrive at some decidable fragments of these theories, a fact that has proved useful in mechanizing proofs. (Received September 15, 2009)

1056-03-76 **Francois Loeser*** (Francois.Loeser@ens.fr), Ecole Normale Superieure, Département de mathématiques et app., 45 rue d'Ulm, 75230 Paris, France. *Model theory and non-archimedean tame topology, with a view towards Berkovich spaces.*

In the model theory of algebraically closed valued fields, certain types - called stably dominated - started to play an important role after recent work of Haskell, Hrushovski and Macpherson. These types are, in a sense, controlled by their stable part. In this talk I will present joint work with E. Hrushovski devoted to the study of the topology of spaces of stably dominated types. It follows form our results that these spaces can be considered as tame in Grothendieck's sense. When working over a field with a real valued norm, they are closely related to Berkovich spaces. This allows us to deduce tameness results for the topology of Berkovich spaces that are analytifications of algebraic varieties. In particular we show that such spaces retract onto finite CW-complexes. (Received September 14, 2009)

1056-03-105 **Corneliu A. Bodea**, **Arthur Charlesworth**, **Diana A. Iovan** and **Andrew D. Jones***, 28 Westhampton Way, Department of Mathematics & Computer Science, University of Richmond, Richmond, VA 23173. *Computer-Created Human-Comprehensible Logic Games.* Preliminary report.

A *logic game* is a pair (AxiomSystem, Theorem) consisting of an axiom system and a formal theorem within that axiom system. The human player of the game is challenged to prove the formal theorem using the inference rules of the axiom system. A logic game can also be presented as a multiple choice question for which exactly one of the choices is a provable (alternatively, non-provable) formal theorem. The human player can specify the level of difficulty in the propositional logic games created by our software.

A *model* of an axiom system is an interpretation of the axioms such that all the axioms are true. Our computer system integrates a component for simultaneously creating axioms as it selects the inference rules in the proof of the eventual theorem, a component using forward-chaining to discover formal theorems from axioms, and a component using models ensuring that the created axiom system is consistent and does not have redundant axioms. (Received July 27, 2009)

1056-03-159 **Rachel Epstein*** (epstein@uchicago.edu), Department of Mathematics, University of Chicago, 5734 S University Ave, Chicago, IL 60637. *Invariance and Automorphisms of the Computably Enumerable Sets.*

The class of computably enumerable (c.e.) sets forms a lattice $\mathcal{E}$ under inclusion. We say a class of c.e. degrees is *invariant* if it is the set of degrees of a class of c.e. sets that is invariant under automorphisms of $\mathcal{E}$. The upward closed jump classes $\bar{L}_n$ and $\mathrm{H}_n$ have all been shown to be invariant, except for $\bar{L}_1$. We show that $\bar{L}_1$ is noninvariant, proving a 1996 conjecture of Harrington and Soare. (Received August 07, 2009)

1056-03-214 **Amy Turlington*** (turlington@math.uconn.edu). *Computable distributive lattices and Heyting algebras.*

We provide several results on computable distributive lattices, particularly pseudocomplemented distributive lattices and Heyting algebras. First, we prove that it is always possible to find a computable maximal (or minimal) prime ideal in a computable (pseudocomplemented) distributive lattice or Heyting algebra. We then investigate the computable dimension of these structures. A main result here is that the free Heyting algebra on infinitely many generators has computable dimension $\omega$. (Received August 15, 2009)

1056-03-262 **Philip Ehrlich*** (ehrlich@ohio.edu), Department of Philosophy, Ohio University, Athens, OH 45701. *Surreal Numbers, Conway Names, and the Simplicity Hierarchy.*

J. H. Conway's ordered field No of surreal numbers is so remarkably inclusive that, subject to the proviso that numbers–construed here as members of ordered "number" fields–be individually definable in terms of sets of NBG, it may be said to contain "All Numbers Great and Small." In addition to its inclusive structure as an ordered field, No has a rich algebraico-binary tree-theoretic structure, or simplicity hierarchy, that emerges from the recursive clauses in terms of which it is defined. Among the striking simplicity-hierarchical features of No is that every surreal number can be assigned a canonical "proper name"–called its Conway name (or normal form)–that is a reflection of its characteristic simplicity-hierarchical properties. In the present talk, answers are provided for the following two questions that are motivated by No's structure as an ordered binary tree:

(i) Given the Conway name of a surreal number, what are the Conway names of its two immediate successors?

(ii) Given a chain of surreal numbers of infinite limit length, what is the Conway name of the immediate successor of the chain? (Received August 21, 2009)

1056-03-649 **Julia F. Knight***, knight.1@nd.edu, and **Karen Lange**, klange1@nd.edu. *Generalized power series and real closed fields: Part II.*

Mourgues and Ressayre showed that every real closed field has an integer part. Their construction involves mapping the given real closed field $R$ isomorphically onto a truncation closed sub-field of the field $k\langle\langle G\rangle\rangle$, where $G$ is the natural value group of $R$ and $k$ is the residue field. We refer to the image of $r \in R$ as its *development.* If $G$ has cardinality $\kappa$, then the developments may have arbitrary ordinal length less than $\kappa^+$. We consider the case where $R$ is countable, and we list the elements of a transcendence base for $R$ over $k$—$r_1, r_2, \ldots$. In terms of this list, the Mourgues and Ressayre construction becomes canonical. Let $R_n$ be the real closure of $R_n(r_1, \ldots, r_n)$. By a result of Shepherdson, the elements of $R_1$ have developments of length at most $\omega$. We show that elements of $R_n$ have developments of length at most $\omega^{\omega^{(n-1)}}$. Thus, the elements of $R$ have developments of length less than $\omega^{\omega^\omega}$. These bounds are sharp. Letting $G$ be generated by a single infinitesimal, we produce a sequence of elements $r_1, r_2, \ldots$ such that for each $n \geq 1$, $R_n$ contains an element whose development has length $\omega^{\omega^{(n-1)}}$. (Received September 15, 2009)

1056-03-678 **Julia Knight** (Julia.F.Knight.1@nd.edu), Department of Mathematics, 255 Hurley Hall, Notre Dame, IN 46556-4618, and **Karen Lange*** (klange1@nd.edu), Department of Mathematics, 255 Hurley Hall, Notre Dame, IN 46556-4618. *Generalized power series and real closed fields, Part I.*

An *integer part* $I$ of a real closed field $R$ is a discrete ordered subring containing 1 such that for all $r \in R$ there exists a unique $i \in I$ with $i \leq r < i + 1$. Shepherdson showed that $I$ is an integer part for a real closed field if and only if $I$ is a model of *IOpen*, the fragment of arithmetic with induction axioms restricted to quantifier-free formulas. Mourgues and Ressayre later 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 of $R$ by building an isomorphism between $R$ and a truncation closed subfield of $k\langle\langle G\rangle\rangle$. In order to understand the complexity of integer parts, we analyze an algorithmic version of the Mourgues and Ressayre construction and provide upper bounds on the ordinal lengths of the generalized power series in the image of $R$. These bounds are then used to show that every computable real closed field has an integer part of complexity $\Delta^0_{\omega^\omega}$. (Received September 15, 2009)

1056-03-987 **Lou van den Dries*** (vddries@math.uiuc.edu), Department of Mathematics, University of Illlinois, Urbana/Champaign, IL 61801. *Recent work on H-fields.*

I will discuss my recent work (joint with Matthias Aschenbrenner and Joris van der Hoeven) on H-fields. (Received September 19, 2009)

1056-03-1098 **Ovidiu Costin*** (costin@math.ohio-state.edu), 231 w 18th ave, Math Tower, Columbus, OH 43210. *Surreal numbers and real analysis.*

A major open problem in surreal number theory is whether there exists a definite integral satisfying the basic properties of integration, and applicable to a wide enough class of functions (including say at least all elementary and special functions).

The implications to (usual) analysis of surreal integration, if indeed one exists, are likely to be major, for instance in understanding the global behavior of solutions of ODEs and PDEs.

I will describe the question, its importance, the progress made and remaining difficulties.

Work in collaboration with M. D. Kruskal. (Received September 20, 2009)

1056-03-1592 **Tyler J Markkanen*** (tmarkkanen@smwc.edu), Department of Sciences and Mathematics, Saint Mary-of-the-Woods College, Hulman Hall, Room 316, St Mary-of-the-Woods, IN 47876. *"Separating the Degree Spectra of Structures" and Beyond: An Overview of My Dissertation in Computable Model Theory with Some New Extensions.*

In computable model theory, the (Turing) degree spectrum of a countable structure $\mathfrak{A}$ is the set $\mathrm{DgSp}(\mathfrak{A}) = \{\deg_T(\mathfrak{B}) : \mathfrak{B} \cong \mathfrak{A}\}$ and is one way to measure the computability of $\mathfrak{A}$. Given various *classes* of structures, such as linear orders, groups, and graphs, we separate two classes $\mathcal{K}_1$ and $\mathcal{K}_2$ in the following way: we say that $\mathcal{K}_1$ is *distinguished from* $\mathcal{K}_2$ *with respect to degree spectrum* if there is an $\mathfrak{A} \in \mathcal{K}_1$ whose degree spectrum is not that of any $\mathfrak{B} \in \mathcal{K}_2$. We will investigate this separation idea and look at specific choices for $\mathcal{K}_1$ and $\mathcal{K}_2$ — for example, we show that with respect to degree spectrum, linear orders are distinguished from finite-component graphs, equivalence structures, rank-1 torsion-free abelian groups, and daisy graphs. From these proofs we will see a pattern for the structures from which linear orders are distinguished. With a goal to find more examples, we will also consider certain structures involving types (from classical model theory) and increasingly nested families (i.e., families of sets, families of families of sets, etc.). (Received September 22, 2009)

1056-03-1682 **Paul Baginski*** (baginski@math.univ-lyon1.fr), Institut Camille Jordan, Batiment Braconnier, 21 Avenue Claude Bernard, 69622 Villeurbanne, France. *Model Theory of Stable Groups.*

In the late 70s, Baur, Cherlin and Macintyre, and independently, Felgner, proved that a stable $\aleph_0$-categorical group is nilpotent by finite. The first set of authors conjectured further that such a group would necessarily be abelian by finite. At the same time, Baldwin and Rose proved an analogous result about rings: 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. up to extension by a finite ring, multiplication is trivial. The group and ring conjectures are in fact equivalent. We shall discuss recent developments for trying to prove the Baur-Cherlin-Macintyre conjecture and for understanding possible counterexamples that may arise. (Received September 22, 2009)

# 05 ► Combinatorics

1056-05-16 **Richard P. Stanley*** (rstan@math.mit.edu), Department of Mathematics, M.I.T., Cambridge, MA 02139. *Increasing and decreasing subsequences.*

The three lectures will be on permutations of finite sets, focusing on combinatorics but including connections with many other areas. The lectures will be mostly independent from each other and aimed at a general mathematical audience. The first lecture will cover increasing and decreasing subsequence of permutations of $1, 2, \ldots, n$. It will cover such topics as connections with Young tableaux and the RSK algorithm, the expected length and limiting distribution of the length of the longest increasing subsequence of a permutation of $1, 2, \ldots, n$, and an analogous theory for matchings. (Received August 26, 2009)

1056-05-17 **Richard P. Stanley*** (rstan@math.mit.edu), Department of Mathematics, M.I.T., Cambridge, MA 02139. *Alternating permutations.*

An *alternating permutation* $w = a_1 \cdots a_n$ of $1, 2, \ldots, n$ is a permutation such that $a_i > a_{i+1}$ if and only if $i$ is odd. If $E_n$ (called an *Euler number*) denotes the number of alternating permutations of $1, 2, \ldots, n$, then $\sum_{n \geq 0} E_n \frac{x^n}{n!} = \sec x + \tan x$. We will discuss such topics as other occurrences of Euler numbers in mathematics, umbral enumeration of classes of alternating permutations, longest alternating subsequences of permutations, and a connection with the *cd*-index of the symmetric group $\mathfrak{S}_n$. The *cd*-index is a noncommutative polynomial in the variables $c$ and $d$ that encodes the number of permutations $a_1 \cdots a_n \in \mathfrak{S}_n$ with specified values of $i$ for which $a_i > a_{i+1}$. (Received August 26, 2009)

1056-05-18 **Richard P. Stanley*** (rstan@math.mit.edu), Department of Mathematics, M.I.T., Cambridge, MA 02139. *Reduced decompositions.*

Let $s_i$ denote the adjacent transposition $(i, i+1) \in \mathfrak{S}_n$, $1 \leq i \leq n-1$. A *reduced decomposition* of a permutation $w \in \mathfrak{S}_n$ is a sequence $(b_1, \ldots, b_p)$ for which $w = s_{b_1} \cdots s_{b_p}$ and $p$ is minimal. A basic problem is to determine the number $r(w)$ of reduced decompositions of $w$. This problem leads to a rich theory involving Young tableaux, symmetric functions, a version of the RSK-algorithm, Schubert polynomials, Schur and Weyl modules, flag varieties, etc. (Received August 26, 2009)

1056-05-60 **Patrick Bahls*** (pbahls@unca.edu), CPO #2350, One University Heights, Asheville, NC 28804-8511. *The $L(2,1)$ channel-assignment problem on trees.* Preliminary report.

Let $G = (V, E)$ be a simple graph. We say that a non-negative integer labeling $\ell$ of its vertices $V$ is called an *$L(2,1)$-labeling* if for every pair $\{u, v\}$ of adjacent vertices $|\ell(u) - \ell(v)| \geq 2$, and for every pair $\{u, v\}$ satisfying $\rho(u, v) = 2$, $|\ell(u) - \ell(v)| \geq 1$, where $\rho$ is the usual path metric on $V$. (Such labelings model the assignment of non-interfering "channels" to nearby radio transmitters.) The *$L(2,1)$-span* of a graph $G$, $\lambda(G)$, is defined to be the minimum value, over all $L(2,1)$-labelings of $G$, of $\max_{v \in V} \ell(v)$.

In 1992 J.R. Griggs and R.K. Yeh proved that for a tree $T$ with maximal vertex degree $\Delta$, $\lambda(T) \in \{\Delta + 1, \Delta + 2\}$, but conjectured that for an arbitrary tree determining which of these values obtains would prove to be NP-hard.

We describe a deterministic algorithm for computing $\lambda(T)$ in the case $\Delta = 3$ and indicate how this algorithm can be generalized to arbitrary maximal degree $\Delta$. The algorithm has exponential time complexity, and its construction shows why no more efficient deterministic algorithm can be found. (Received July 21, 2009)

1056-05-79 **Kassandra A Johnston*** (kjohns05@unm.edu), 8727 Beacon Woods PL, Fort Wayne, IN 46804, and **Philip R Zerull** (zerul1pr@cmich.edu) and **Sivaram K Narayan** (sivaram.narayan@cmich.edu), Department of Mathematics, Central Michigan University, Mount Pleasant, MI 48859, and **Jordan D Webster** (webst1jd@cmich.edu), Department of Mathematics, Central Michigan University, Mount Pleasant, MI 48859. *Subgraph Summability Number.* Preliminary report.

The Subgraph Summability number, $\sigma(G)$, of a connected graph $G$ is the largest integer defined by labeling the vertices of $G$ so that the label sums of connected induced subgraphs cover the set of positive integers $\{1, 2, ..., \sigma(G)\}$. This is a generalization of problems in number theory and design theory. In this talk we present subgraph summability numbers of certain graph classes including double star, crown, and broom graphs. (Received July 22, 2009)

1056-05-134 **Sara D. Townsend*** (cera22dt@yahoo.com), 88A Piney Point Road, Huntsville, TX 77340, and **Suzi Gearheart** and **John Owen**. *The Relative Gain Array of Cayley Graphs.*

The relative gain array (RGA) is a matrix function which has applications to chemical engineering. When one explores iterates of this function, one of four things will occur. If the input matrix A is singular then RGA(A) is zero. If A is nonsingular then in some rare cases, A is fixed by the relative gain array. In other cases, iterates of the function RGA converges to a fixed matrix. And finally, in some cases, iterates of the RGA display chaotic behavior.

A Cayley graph is a graph with a sharply transitive automorphism group. We explore the RGA of various Cayley graphs. Using both Mathematica and Groups Algorithms and Progamming (GAP), we observe the four different behaviors of the RGA. We analyze the defining set S in an attempt to predict the behavior of the relative gain array. We compare the action of the RGA on a Cayley graph with the action of the RGA on the complementary graph. We are especially interested in cases in which either the adjacency algebra (of either the graph or its complement) is closed under the Hadamard product. (Received July 29, 2009)

1056-05-142 **Sandra James*** (jamess@csp.edu), Mathematics Department, 275 Syndicate Street North, Concordia University - St. Paul, St. Paul, MN 55104, and **Andrew Zemke** (drew.zemke@gmail.com), School of Mathematical Sciences, 85 Lomb Memorial Drive, Rochester Institute of Technology, Rochester, NY 14623. *Greedy Algorithms for Generalized $k$-rankings of graphs.*

A $k$-ranking of a graph is a labeling of the vertices with positive integers $1, 2, \cdots, k$ so that every path connecting two vertices with the same label contains a vertex of larger label. An optimal ranking is one in which $k$ is minimized. Let $G$ be a graph containing a Hamiltonian path on vertices $v_1, v_2, \cdots, v_n$ but no Hamiltonian cycle. We use a greedy algorithm to successively label the vertices assigning each vertex with the smallest possible label that preserves the ranking property. We show that when $G$ is a path the greedy algorithm generates an optimal $k$-ranking. We then investigate two generalizations of rankings. We first consider bounded $(k, s)$-rankings in which the number of times a label can be used is bounded by a predetermined integer $s$. We then consider $k_t$-rankings where any path connecting two vertices with the same label contains $t$ vertices with larger labels. We show for both generalizations that when $G$ is a path, the analogous greedy algorithms generate optimal $k$-rankings. (Received August 31, 2009)

1056-05-143 **Kevin Black*** (Kevin_Black@HMC.Edu), Department of Mathematics, 301 Platt Boulevard, Harvey Mudd College, Claremont, CA 91711, and **Daniel Leven** (danlev151@gmail.com), Department of Mathematics, Rutgers University - Hill Center, 110 Frelinghuysen Rd, Piscataway, NJ 08854-8019. *Finding Ramsey Numbers.*

The Ramsey number $R(G,H)$ is the smallest positive integer $n$ such that any graph on $n$ vertices contains $G$ as a subgraph or $H$ in the complement. We derive a new upper bound of 26 for the Ramsey number $R(K_5-P_3,K_5)$, improving on the previous upper bound of 28. This leaves $25 \leq R(K_5-P_3,K_5) \leq 26$.

We also show, with the help of a computer, that $R(B_2,B_6)=17$ and $R(B_2,B_7)=18$ by full enumeration of $(B_2,B_6)$-good graphs and $(B_2,B_7)$-good graphs, where $B_n$ is the book graph with $n$ triangular pages. (Received August 01, 2009)

1056-05-146 **Chencong Bao**, **Camila Friedman-Gerlicz** and **Peter McGrath*** (mcgrathp@lafayette.edu), Lafayette College, Math Dept, Easton, PA 18042, and **Jessica Vega**. *Matroids, Geometry, Symmetry and the 4th Dimension.*

We describe the automorphism group of a certain rank 4 matroid on 60 points that arises from the root system H4. There is a close connection to two dual regular 4-dimensional solids: the 120-cell and the 600-cell. (Received August 01, 2009)

1056-05-162 **Svetlana Poznanović*** (spoznan@math.tamu.edu). *A Bijection Between Partially Directed Paths in the Symmetric Wedge and Matchings.*

I will illustrate a bijection between partially directed paths in the symmetric wedge $y=\pm x$ and matchings, which sends the number of north steps to the number of pairs of edges nested one below the other (nestings). This gives a bijective proof of a result of Prellberg et al. that was first discovered through the corresponding generating functions: the number of partially directed paths starting at the origin confined to the symmetric wedge $y=\pm x$ with $k$ north steps is equal to the number of matchings on $[2n]$ with $k$ nestings. (Received September 22, 2009)

1056-05-166 **Anthony A. Mendes*** (aamendes@calpoly.edu), Anthony Mendes, Mathematics Department, 1 Grand, Ave., Cal Poly, San Luis Obispo, CA 93407. *Matrix Bijections.*

Let $A$ and $B$ be square matrices with entries which count collections of signed, weighted objects. Given an explicit bijection proving that $AB=I$, we can automatically produce an explicit bijection proving that $BA=I$. Our construction involves a modification of the Garsia-Milne involution principle. Given a matrix A, our methods can also produce a signed, weighted collection of objects which describe the entries of $A^{-1}$. The results in this talk are joint work with Nick Loehr. (Received August 10, 2009)

1056-05-168 **Donald E. Knuth***, Computer Science Department, Stanford University, Stanford, CA 94305-9045. *Permutation problems.*

The speaker will discuss various problems associated with permutations that he has encountered during the past 50 years or so. (Received August 11, 2009)

1056-05-199 **Beth Malmskog*** (malmskog@math.colostate.edu), 527 E. Prospect, Fort Collins, CO 80525, and **Michelle Manes**. *Ihara Zeta Functions and Some Ramified Covers of Graphs.*

The Ihara zeta function of a graph was defined in the 1960s and shares some properties with other zeta functions, including convergence to a rational function. This poster presents an "almost" divisibility relationship between the Ihara zeta functions of some ramiﬁed covers of graphs, proven in collaboration with Michelle Manes. Background material, important examples, and the main ideas of the proof of our main result are presented, highlighting example graphs of concepts when relevant. (Received August 14, 2009)

1056-05-226 **Ralucca M Gera*** (rgera@nps.edu), 1 University Way, Monterey, CA 93943, and **Henry Escuadro**, **Pranav Anand** and **Craig Martell**. *The Link Graph: a Tool for Word Sense Disambiguation.*

One of the chief concerns of linguists is the ambiguity of natural language. At the lexical level, this manifests in the existence of the multiplicity of senses that a word may have. A natural representation for the outcome of this procedure is a graph, were V is the vocabulary (the set of distinct words in the text) and vertices are adjacent in iff the words they represent co-occur in a relevant pattern in the text. Ideally, the words in the same semantic field thus give rise to a component of the graph. However, when words that have multiple senses are part of the graph, this is not the case.

In response, Dorow et al. provide an algorithm that transforms the graph into a new graph, for which generally each individual component contains only one meaning of the polysemous words. They introduced the link graph, a subgraph and another version of the line graph. Given a graph $G$, the *link graph* of $G$, denoted by $LK(G)$, is the graph obtained from $G$ by replacing each edge $\ell$ of $G$ by a vertex $v_\ell$, and then joining two vertices in $LK(G)$ iff the corresponding edges in $G$ belong to a $K_3$ in $G$. This paper studies general properties of $LK(G)$ for an arbitrary graph $G$, with full characterization for $G \cong K_n$. (Received August 17, 2009)

1056-05-230 **Neil J.A. Sloane*** (njas@research.att.com), 180 Park Ave., Room C233, Florham Park, NJ 07932-0971. *The Toothpick Sequence and Other Sequences from Cellular Automata.* Preliminary report.

The toothpick sequence was invented by Omar Pol (in Buenos Aires). One starts by placing a single toothpick of length 1 on a square grid. At each subsequent stage, for every exposed toothpick end, place an orthogonal toothpick centered at that end. The result has a remarkable fractal-like structure (which will be illustrated by a movie), and the number of toothpicks added at each stage satisfies an unusual recurrence and generating function. Some related sequences generated by two-dimensional cellular automata will also be discussed. This is joint work with David Applegate. (Received August 19, 2009)

1056-05-249 **Eric S Egge*** (eegge@carleton.edu), Department of Mathematics, Carleton College, Northfield, MN 55057. *Symmetric Permutations with No Long Decreasing Subsequences.*

It is well-known that the number of permutations in $S_n$ with no decreasing subsequence of length 3 is the Catalan number $C_n = \frac{1}{n+1}\binom{2n}{n}$. Several authors have enumerated the permutations in $S_n$ with no decreasing subsequence of length 4, and Gessel has used symmetric functions to express the generating function for permutations in $S_n$ with no decreasing subsequence of length $k$ as a determinant of Bessel functions. In this talk we describe how to use the Robinson-Schensted-Knuth correspondence and the combinatorics of tableaux to enumerate permutations in $S_n$ with no descreasing subsequence of length $k$ whose diagrams are rotationally symmetric. (Received August 19, 2009)

1056-05-253 **John Paul Steinberger*** (jpsteinb@gmail.com), 1-208 FIT Building, Tsinghua University, Beijing, 100084, Peoples Rep of China. *A new proof of the four-color theorem.*

We give a new proof of the four-color theorem by exhibiting an unavoidable set of D-reducible configurations. This settles a conjecture (first stated by Stromquist and by Appel and Haken, later reiterated by Robertson, Seymour, Sanders and Thomas) open since the 70s. (Received August 20, 2009)

1056-05-281 **Daniel W Cranston***, Department of Math and Applied Math, Virginia Commonwealth University, Richmond, VA 23284, and **Gexin Yu**. *Detecting a Machine Failure in a Network: Vertex Identifying Codes.*

Given a graph $G$, an identifying code $C \subseteq V(G)$ is a vertex set such that for any two distinct vertices $v_1, v_2 \in V(G)$, the sets $N[v_1] \cap C$ and $N[v_2] \cap C$ are distinct and nonempty (here $N[v]$ denotes a vertex $v$ and its neighbors). We study the case when $G$ is the infinite hexagonal grid $H$. Cohen et.al. constructed two identifying codes for $H$ with density 3/7 and proved that any identifying code for $H$ must have density at least $16/39 \approx 0.410256$. Both their upper and lower bounds were best known until now. Here we prove a lower bound of $12/29 \approx 0.413793$. (Received August 24, 2009)

1056-05-287 **Joanna Anthony Ellis-Monaghan*** (jellis-monaghan@smcvt.edu), Saint Michael's College, One Winooski Park, Colchester, VT 05439, and **Greta Pangborn** (gpangborn@smcvt.edu), Saint Michael's College, One Winooski Park, Colchester, VT 05439. *Graph invariants from self-assembling nanostructures.*

Recent advances in DNA self-assembly have resulted in nanoscale graphs: cubes, octahedrons, truncated octahedra, and even buckyballs, as well as ultra-fine meshes. These constructs serve emergent applications in biomolecular computing, nanoelectronics, biosensors, drug delivery systems, and organic synthesis. One construction method uses $k$-armed branched junction molecules, called tiles, whose arms are double strands of DNA with one strand extending beyond the other, forming a 'sticky end' at the end of the arm that can bond to any other sticky end with complementary Watson-Crick bases. A vertex of degree $k$ in the target graph is formed from a $k$-armed tile, and joined sticky ends form the edges. We use graph theory to determine optimal design strategies for biologists producing these nanostructures. We define two new numerical graph invariants, the minimum number of tiles and minimum number of edge types necessary to create a given graph under three different laboratory scenarios. We determine these values for common graph classes (complete, bipartite, trees, regular, Platonic and Archimedean, etc.). For these classes of graphs, we provide either explicit descriptions of the set of tiles achieving the minimums or efficient algorithms for generating the desired set. (Received August 25, 2009)

1056-05-313 **Wasin So*** (so@math.sjsu.edu), Department of Mathematics, San Jose State University, San Jose, CA 95192. *Non-existence of circulant expander family.* Preliminary report.

The expansion constant of a simple graph $G$ of order $n$ is defined as

$$h(G) = \min_{0<|S|\leq \frac{n}{2}} \frac{|E(S,\overline{S})|}{|S|}$$

where $E(S,\overline{S})$ denotes the set of edges in $G$ between the vertex subset $S$ and its complement $\overline{S}$. An expander family is a sequence $\{G_i\}$ of $d$-regular graphs of increasing order such that $h(G_i) > \epsilon$ for some fixed positive integer $d$ and $\epsilon > 0$. Existence of such family is known in literature, but construction is non-trivial. A folklore states that there is no expander family of circulant graphs only. In this talk, we provide a simple proof of this fact by first estimating the second largest eigenvalue of a circulant graph, and then employing the Cheeger inequality. (Received August 28, 2009)

1056-05-326 **Bill Kay*** (kayw@mailbox.sc.edu), 1821 Greene St., Columbia, SC 29201, and **Joshua Cooper**. *On Graham's Tree Reconstruction Conjecture.*

Suppose $G$ is a tree. If we are given only the integer sequence $(|V|, |V^1|, |V^2|, ...)$ where $V^k = V(L^k(G))$ is the $k^{\text{th}}$ iterated line graph's vertex set, is it possible to determine the original tree? This question ("Graham's Tree Reconstruction Conjecture") has only been answered for very limited classes of graphs. First, we show that certain obvious counter-examples cannot exist. Then we proceed to use the theory of partitions to bound the number of steps it could take to determine the original tree. In this paper, we are able to show that the trees break into quadratically many equivalence classes after the first line graph. Next, we study a closely related problem: Define $A_G$, the *adjacency matrix* of a graph $G$ on $n$ vertices, as the $n \times n$ matrix $\{a_{i,j}\}_{i,j=1}^n$ with $a_{ij} = 1$ if $\{i,j\} \in E(G)$, 0 otherwise. Denote by $W_k$ the quantity $\mathbf{1}^\intercal A_G^k \mathbf{1}$, where $\mathbf{1}$ is the all 1's vector, i.e., the number of walks of length $k$ in $G$. Call the sequence $\{W_k\}_{k=0}^\infty$ the *walk sequence* of a graph. We apply ideas from spectral and fractional graph theory to obtain results about the walk sequences and their connection to the "Graham's Tree Reconstruction Conjecture." (Received August 29, 2009)

1056-05-333 **Ryan Martin*** (rymartin@iastate.edu), 396 Carver Hall, Department of Mathematics, Iowa State University, Ames, IA 50010. *Tiling in Multipartite Graphs.*

We present some results on tiling (or packing) graphs in multipartite graphs. This is a question very similar to the Hajnal-Szemerédi theorem, which gives sufficient minimum-degree conditions for an $n$-vertex graph to have a subgraph of $\lfloor n/r \rfloor$ vertex-disjoint copies of $K_r$. We consider a multipartite version. That is, given an $r$-partite graph with $N$ vertices in each partition, what is the minimum-degree required of the bipartite graph induced by each pair of color-classes so that it contains $N$ vertex-disjoint copies of $K_r$? When $r = 3$ and $N$ is sufficiently large, a degree condition of $(2/3)N$ is sufficient with the exception of a single graph when $N$ is an odd multiple of 3. When $r = 4$ and $N$ is sufficiently large, a degree condition of $(3/4)N$ is sufficient and there is no exceptional graph. There are also bounds on the degree condition for $r > 4$ by Csaba and Mydlarz.

This question has also been generalized to finding minimum-degree conditions for packings of some arbitrary $r$-colorable graph. The case $r = 2$ was answered precisely by Zhao. The case $r = 3$ is more complex and we provide some tight bounds on the required degree condition.

This talk includes joint work with Csaba Magyar, with Endre Szemerédi and with Yi Zhao. (Received August 30, 2009)

1056-05-344 **Arthur H. Busch**, **Michael J. Ferrara** and **Stephen G. Hartke*** (hartke@math.unl.edu), Dept of Mathematics, Univ of Nebraska, 203 Avery Hall, P.O. Box 880130, Lincoln, NE 68588-0130, and **Michael S. Jacobson**, **Hemanshu Kaul** and **Douglas B. West**. *A Generalization of Kundu's k-Factor Theorem.* Preliminary report.

Given nonnegative integer lists $d_1, d_2, \ldots, d_j$, the degree sequence packing problem is to determine if there exist edge-disjoint graphs $G_1, G_2, \ldots, G_j$ on the same vertex set such that $G_i$ has degree sequence $d_i$. A famous example of a result on degree sequence packing is Kundu's $k$-factor theorem, which states that if $d$ is a graphic sequence, and if the sequence $d'$ obtained by adding $k$ to each entry of $d$ is also graphic, then there exists a graph $G$ with degree sequence $d$ and an edge-disjoint $k$-regular graph on the same vertex set. We will consider extensions to Kundu's theroem, particularly when a graphic sequence can be packed with multiple 1-regular graphs. (Received August 31, 2009)

1056-05-428 **Kendra Killpatrick*** (Kendra.Killpatrick@pepperdine.edu), Natural Science Division, 24255 Pacific Coast Hwy, Malibu, CA 90263-4321. *Symmetry and Log-Concavity Results for the Fibmaj Statistic.* Preliminary report.

Fibonacci tableaux were first defined by Richard Stanley in 1975. Since then, much work has been done on Fibonacci tableaux that parallels results known for the well studied Young tableaux. In particular, a major index statistic called the Fibmaj statistic can be defined on Fibonacci tableaux that is analogous to the major index that can be defined for Young tableaux. In my talk, I will give the definition of the Fibmaj statistic for Fibonacci tableaux and show that this statistic is both symmetric and log-concave over all Fibonacci tableaux of a given shape $\mu$. In addition, I will translate the Fibmaj statistic on Fibonacci tableaux to a statistic on Fibonacci permutations and share several conjectures about this statistic. (Received September 06, 2009)

1056-05-441 **Daniel Cranston*** (dcranston@vcu.edu), **Bill Kinnersley**, **Kevin Milans**, **Greg Puleo** and **Douglas West**. *Maker-Breaker Games: Building a Big Chain in a Poset.*

In a *maker-breaker game*, we fix a base set $X$ and a collection of winning subsets $F$. The players Maker and Breaker alternate choosing elements from $X$ and Maker wins if he eventually chooses all the elements in some subset in $F$. Otherwise Breaker wins. We consider the problem when $X$ is the elements of a poset $P$ and $F$ is the collection of chains in $P$ of a given length. When the poset $P$ is a product of chains, we determine precisely the maximum length chain in $P$ that Maker can attain.

We also study the problem when the poset is the d-dimensional $k$-wedge, $W_k^d = \{(x_1, x_2, \ldots, x_d) : 0 \leq x_i \text{ and } \sum_{i=1}^d x_i < k\}$, where $y \leq_{W_k^d} z$ if $y_i \leq z_i$ for all $i$. In this case, we add the restriction that Maker must choose the elements of $W_k^d$ in the order in which they appear in his winning chain. We show that for $W_k^2$, Maker can attain a chain of size $\lceil 2k/3 \rceil$, but no larger. In contrast, we use connections with Conway's Angel/Devil game to show that when $d \geq 14$, Maker can attain a chain of maximum size. (Received September 07, 2009)

1056-05-457 **T. Kyle Petersen*** (tpeter21@depaul.edu), Department of Mathematical Sciences, DePaul University, 2320 N. Kenmore, Chicago, IL 60614, and **Eran Nevo**, Department of Mathematics, Cornell University, Ithaca, NY 14853. *Combinatorial interpretations for $\gamma$-vectors.*

Gal has conjectured that the $h$-polynomial of any flag homology sphere has a nonnegative expansion in the so-called $\gamma$-*basis*: $\{t^i(1+t)^{n-2i}\}$, where $n$ is the degree of $h(t)$. We show that in many cases (e.g., for Coxeter complexes) the $\gamma$-vector is not simply nonnegative, but it is in fact a *Kruskal-Katona vector*. That is, the $\gamma$-vector is the $f$-vector of some other simplicial complex. We conjecture the same to be true of any flag homology sphere, refining significantly Gal's conjecture.

The first example here is the $h$-polynomial of the type $A_n$ Coxeter complex, better known as the *Eulerian polynomial*: the generating function for descents of permutations in $S_{n+1}$. (Received September 08, 2009)

1056-05-467 **Steven Klee***, University of Washington, Department of Mathematics, Box 354350, Seattle, WA 98154. *Lower Bounds for Balanced Simplicial Complexes.*

Barnette's Lower Bound Theorem establishes that a stacked $d$-polytope on $n$ vertices has the minimal $f$-numbers among all simplicial $d$-polytopes on $n$ vertices. We say that a $(d-1)$-dimensional simplicial complex is *balanced* if its 1-skeleton, viewed as a graph, is $d$-colorable. We define a balanced analogue of a stacked polytope by taking connected sums of cross polytopes, and we prove that such a polytope has minimal $f$-numbers among all balanced $d$-polytopes on $n$ vertices. (Received September 08, 2009)

1056-05-473 **Sergey Kitaev*** (Sergey@ru.is). *Enumerating (2+2)-free posets by the number of minimal elements and other statistics.*

A poset is said to be (2+2)-free if it does not contain an induced subposet that is isomorphic to 2+2, the union of two disjoint 2-element chains. In a recent paper, Bousquet-Melou et al. found, using so called ascent sequences, the generating function for the number of (2+2)-free posets. We extend this result by finding a multi-variable generating function for (2+2)-free posets when four statistics are taken into account, one of which is the number of minimal elements in a poset. Also, we give another application of ascent sequences in proving that posets avoiding simultaneously 2+2 and 3+1 are counted by the Catalan numbers.

This is joint work with Jeff Remmel. (Received September 09, 2009)

1056-05-475 **George E. Andrews*** (andrews@math.psu.edu), Mathematics Department, 306 McAllister Bldg., Penn State University, University Park, PA 16828. *Partitions, Orthogonal Polynomials and q-Series.* Preliminary report.

In this talk, we will reexamine the connection coefficient theorems established in the late 1970's with Richard Askey. Our object will be to show why this alternative to Bailey chain methods can provide new insights for the study of partition identities (Received September 09, 2009)

1056-05-476 **W. Andrew Pruett*** (drew_pruett@baylor.edu), 2114 Rawhide Trail, Temple, TX 76502. *Projections of Ocneanu traces are Kazhdan-Lusztig R-polynomials.*

We generalize Deodhar's concept of distinguished subexpressions to Artin's braid group, and show that the resulting notion of $R$-polynomial is well-defined, and is a projection of the Ocneanu trace. This gives a novel algorithm to compute $R$-polynomials over intervals in symmetric groups, and a natural generalization of the Ocneanu trace to arbitrary Weyl groups. (Received September 09, 2009)

1056-05-479 **Aaron Lauda** and **Monica Vazirani*** (vazirani@math.ucdavis.edu), Math Dept, One Shields Ave, Davis, CA 95616. *On Khovanov-Lauda algebras.*

Khovanov-Lauda-Rouquier algebras have played a fundamental role in categorifying quantum groups. I will discuss the structure of their simple modules, in particular that they carry the structure of a crystal graph. This is joint work with Aaron Lauda. (Received September 09, 2009)

1056-05-485 **Jonelle Hook*** (jmh5@lehigh.edu), Christmas-Saucon Hall, 14 E. Packer Ave., Bethlehem, PA 18015. *Star-Avoiding Ramsey Numbers.*

The (graph) Ramsey number $R(G,H)$ is the smallest integer $n$ such that every 2-coloring of the edges of $K_n$ contains either a red copy of G or a blue copy of H and there exists a *critical 2-coloring* of $K_{n-1}$ that does not contain a red copy of G or a blue copy of H. What is the largest star $K_{1,k}$ that can be removed from $K_n$ so that the underlying graph is still forced to have either a red copy of G or a blue copy of H? That is, determine the largest integer $k$ such that every 2-coloring of $K_n - K_{1,k}$ has either a red G or a blue H and there exists a 2-coloring of $K_n - K_{1,k+1}$ without a red G or a blue H. We have determined this integer for various classes of graphs $G$ and $H$ where $R(G,H)$ is known. For these Ramsey numbers, we have also classified the critical 2-colorings. (Received September 09, 2009)

1056-05-487 **Nicholas A. Loehr*** (nloehr@vt.edu), 460 McBryde Hall, Blacksburg, VA 24061-0123, and **Gregory S. Warrington**. *A Continuum of Partition Statistics.*

A well-known partition theorem states that the generating function for integer partitions by area and number of parts is $\prod_{i=1}^{\infty}(1-tq^i)^{-1}$. This talk describes a surprising extension of this result in which the "number of parts" statistic is replaced by other statistics parametrized by positive real numbers. These statistics are defined by looking at certain ratios of arm and leg numbers that also arise in the theory of Macdonald polynomials and Hilbert schemes. We give a bijective proof of the equidistribution of all these statistics. The proof utilizes various combinatorial constructions including cylindrical lattice paths, Eulerian tours on directed multigraphs, and involutions on oriented trees. (Received September 09, 2009)

1056-05-498 **Stephen G Hartke**, **Hannah Kolb**, **Jared Nishikawa** and **Derrick Stolee*** (s-dstolee1@math.unl.edu), P.O. Box 880130, Lincoln, NE 68588. *Deletion relations of graphs.* Preliminary report.

For a graph G, understanding the structure of a vertex-deleted subgraph is useful for several problems in graph theory. Two examples are computing the automorphism group and solving the reconstruction conjecture. This paper raises the question of which (ordered) pairs of groups can be represented as the automorphism groups of a graph and one of its vertex-deleted subgraphs. This, and more surprisingly the analogous question for edge-deleted subgraphs, are answered in the most positive sense using concrete constructions. (Received September 10, 2009)

1056-05-506 **Tyler Seacrest*** (s-tseacre1@math.unl.edu). *Packing Degree Sequences.* Preliminary report.

Let $\pi_1 = (a_1, \ldots, a_n)$ and $\pi_2 = (b_1, \ldots, b_n)$ be two degree sequences. We say that the degree sequences pack if there exist edge disjoint graphs $G_1$ and $G_2$ with the given degree sequences on the same $n$ vertices such that the $i$th vertex has degree $a_i$ in $G_1$ and degree $b_i$ in $G_2$. We give some sufficient conditions for when two degree sequences pack. (Received September 10, 2009)

1056-05-519 **Bruce E Sagan*** (sagan@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824. *Probabilistic proofs of hook length formulas involving trees.*

Let $T$ be a rooted tree with $n$ vertices. We use $T$ to stand for the vertex set of $T$. An *increasing labeling* of $T$ is a bijection $\ell : T \to \{1, 2, \ldots, n\}$ such that $\ell(v) \leq \ell(w)$ for all descendents $w$ of $v$. Let $f^T$ be the number of increasing labelings. The *hooklength*, $h_v$, of a vertex $v$ is the number of descendents of $v$. The hook length formula for trees is

$$f^T = \frac{n!}{\prod_{v \in T} h_v}.$$

There is a similar formula for the number of standard Young tableaux of given shape. Greene, Nijenhuis, and Wilf gave a beautiful probabilistic proof of the tableau formula where the hooklenths enter in a very natural way.

Recently, Han discovered a formula which has the interesting property that hooklengths appear as exponents. Specifically, let $\mathcal{B}(n)$ be the set of all $n$-vertex binary trees. Han proved that

$$\sum_{T \in \mathcal{B}(n)} \prod_{v \in T} \frac{1}{h_v 2^{h_v - 1}} = \frac{1}{n!}$$

using algebraic manipulations. We will show how to give a simple probabilistic proof of this equation as well as various generalizations. We will also pose some open questions raised by this work. (Received September 11, 2009)

1056-05-533 **Jonathan Wang*** (jpwang@fas.harvard.edu), 52 Adams Mail Center, 26 Plympton St., Cambridge, MA 02138. *Thin Lehman Matrices and Their Graphs.*

Two square 0, 1 matrices $A, B$ are a pair of Lehman matrices if $AB^T = J + dI$, where $J$ is the matrix of all 1s and $d$ is a positive integer. It is known that there are infinitely many such matrices when $d = 1$, and these matrices are called thin Lehman matrices. An induced subgraph of the Johnson graph may be defined given any Lehman matrix, where the vertices of the graph correspond to rows of the matrix. These graphs are used to study thin Lehman matrices. We show that any connected component of such a graph determines the corresponding rows of the matrix up to permutations of the columns. We also provide a sharp bound on the maximum clique size of such graphs. A complete classification of Lehman matrices whose graphs have at most two connected components is given. (Received September 11, 2009)

1056-05-536 **Hong-Jian Lai** and **Huiya Yan*** (yan.huiy@uwlax.edu), Mathematics Department, University of Wisconsin-La Crosse, 1725 State Street, La Crosse, WI 54601. *Extremal 2-supereulerian graphs.* Preliminary report.

If a graph contains a spanning eulerian subgraph, then it is called *supereulerian.* Let $m = \min\{c\}$ such that $G$ has a spanning eulerian subgraph with at least $c$ components. If $m \leq k$(integer), then the graph $G$ is called *k-supereulerian.* In this talk, we are going to show that a 2-edge-connected simple graph $G$ of order $n$ is 2-supereulerian if $|E(G)| \geq \binom{n-7}{2} + 10$, and the upper bound is sharp. (Received September 11, 2009)

1056-05-558 **Tao Jiang**, **Bill Kinnersley**, **Kevin G. Milans*** (milans@math.uiuc.edu) and **Douglas B. West**. *Degree Ramsey Numbers of Graphs.* Preliminary report.

A graph $H$ *arrows* a graph $G$ if every 2-edge-coloring of $H$ contains a monochromatic copy of $G$. The *degree Ramsey number* of $G$ is the minimum $k$ such that some graph with maximum degree $k$ arrows $G$. Burr, Erdős, and Lovász found the degree Ramsey number of stars and complete graphs. We establish the degree Ramsey number exactly for double stars and $C_4$, the cycle on four vertices. We prove that the degree Ramsey number of the cycle $C_n$ is at most 108 when $n$ is even and at most 3890 in general. We present a family of graphs in which the degree Ramsey number of $G$ is bounded by a function of the maximum degree of $G$ and ask which graph families have this property. This is joint work with Tao Jiang, Bill Kinnersley, and Douglas B. West. (Received September 12, 2009)

1056-05-576 **Martin Charles Golumbic*** (golumbic@cs.haifa.ac.il), Caesarea Rothschild Institute, University of Haifa, Mt. Carmel, 31905 Haifa, Israel, and **Boi Faltings** (boi.faltings@epfl.ch), Artificial Intelligence Laboratory (LIA), Ecole Polytechnique Fédérale de, Lausanne (EPFL), Lausanne, Switzerland. *An Effective Upperbound on Treewidth Using Partial Fill-in of Separators.*

Partitioning a graph using graph separators, and particularly clique separators, are well-known techniques to decompose a graph into smaller units which can be treated independently. It was previously known that the treewidth was bounded above by the sum of the size of the separator plus the treewidth of disjoint components, and this was obtained by the heuristic of filling in all edges of the separator making it into a clique.

In this paper, we present a new, tighter upper bound on the treewidth of a graph obtained by only partially filling in the edges of a separator. In particular, the method completes just those pairs of separator vertices that are adjacent to a common component, and indicates a more effective heuristic than filling in the entire separator.

We discuss the relevance of this result for combinatorial algorithms and give an example of how the tighter bound can be exploited in the domain of constraint satisfaction problems. (Received September 13, 2009)

1056-05-586 **Lisa Danz*** (ldanz@mit.edu), 1540 Morton Ave., Los Altos, CA 94024. *The optimal t-rubbling number of the complete m-ary tree.* Preliminary report.

Given a graph with pebbles on the vertices, a rubbling move is either a pebbling move, which removes two pebbles from one vertex and adds one pebble to an adjacent vertex, or a strict rubbling move, which removes one pebble from each of two vertices adjacent to a third vertex $u$ and adds one pebble to vertex $u$. The optimal $t$-rubbling number of a graph is the smallest number $n$ for which there exists a distribution of $n$ pebbles among the vertices such that $t$ pebbles can reach any vertex through a sequence of rubbling moves. We investigate the optimal $t$-rubbling number of the complete $m$-ary tree. We find an exact answer for the case $m \geq 3$, and we find a lower bound and an algorithm for the case $m = 2$. For a fixed tree height, we find that the optimal rubbling number achieves the lower bound for all $t$ sufficiently large. (Received September 13, 2009)

1056-05-628 **Ae Ja Yee**, McAllister Bldg, University Park, PA 16802, and **Kagan Kursungoz*** (kursun@math.psu.edu), McAllister Bldg, University Park, PA 16802. *Alternating Permutations and the mth Descents.*

Yee and Huber (2008) defined half-descents on alternating permutations, and derived generating functions that incorporate both the inversions and the half-descents together. In this talk, a generalization of half-descents will be described on an appropriate class of permutations. Two-variable generating functions that incorporate inversions and the $m$th descents will be given. This unifies many previous results, along with new ones. Proofs will be sketched as time allows. A brief but fairly complete background will be given, so the talk is self-contained. This is joint work with Ae Ja Yee (Penn State). (Received September 14, 2009)

1056-05-629 **Chris Rodger** (rodgec1@auburn.edu), 221 Parker Hall, Auburn University, AL 36849, and **Michael Tiemeyer*** (tiemema@auburn.edu), 221 Parker Hall, Auburn University, AL 36849. *$C_4$-Factorizations with Two Associate Classes.*

Let $K = K(a, p; \lambda_1, \lambda_2)$ be the multigraph with: the number of vertices in each part equal to $a$; the number of parts equal to $p$; the number of edges joining any two vertices of the same part equal to $\lambda_1$; and the number of edges joining any two vertices of different parts equal to $\lambda_2$. This graph was of interest to Bose and Shimamoto in their study of group divisible designs with two associate classes. Necessary and sufficient conditions for the existence of $z$-cycle decompositions of this graph have been found when $z \in \{3, 4\}$. The existence of $C_4$-factorizations of $K$ has been settled when $a$ is even, but the odd case is much more difficult. In this paper, necessary and sufficient conditions for the existence of a $C_4$-factorization of $K(a, p; \lambda_1, \lambda_2)$ are found when $a \equiv 1 (mod\, 4)$. (Received September 14, 2009)

1056-05-651 **Suzanne I Doree*** (doree@augsburg.edu). *Simultaneous and non-simultaneous Bulgarian Exchange.* Preliminary report.

We introduce Bulgarian Exchange, a two-player variant of the process dubbed Bulgarian Solitaire by Martin Gardner in 1983. Two players begin with coins arranged in piles. At each turn, a player gathers one coin from each pile and hands this collected pile to the other player. The exchange may be simultaneous or in succession. In either case the process may be viewed as an operator on the space of multi-partitions and may be visualized using Ferrers diagrams – one player deletes her longest column and the other player inserts it as her new row. We characterize the terminal states, cycle lengths, and count the number of disjoint cycles (i.e. components of the state graph) in both the simultaneous and non-simultaneous cases. This work generalizes the results of the solitaire version. (Received September 22, 2009)

1056-05-674 **Catherine Yan*** (cyan@math.tamu.edu), Department of Mathematics, Texas A&M University, MS 3368, College Station, TX 77843-3368, and **Dimitrije Kostic**. *Multiparking Functions, Graph Search, and Tutte Polynomial.*

We present the relation between parking functions and the Tutte polynomial of a general graph $G$ by a combinatorial approach. The main step is to construct a family of graph searching algorithms which induce bijections between the spanning forests of a graph and the generalized parking functions associated with the graph. In particular, the bijection induced by the breadth-first search leads to a new characterization of the external activity, and hence a representation of Tutte polynomial. (Received September 15, 2009)

1056-05-690 **Shanzhen Gao*** (sgao2@fau.edu), Department of Mathematics, Florida Atlantic University, 777 Galdes Road, Boca Raton, FL 33431. *Some Remarks On Self-Avoiding Walks.*

A self-avoiding walk (SAW) is a sequence of moves on a lattice which does not visit the same point more than once. A SAW is interesting for simulations because its properties cannot be calculated analytically. Calculating the number of self-avoiding walks in any given lattice is a common computational problem. We will present some interesting problems involving prudent self-avoiding walks and pattern avoiding, and show how to solve a few of them. (Received September 15, 2009)

1056-05-704 **Francois Bergeron*** (bergeron.francois@uqam.ca), Departement de Mathematiques, UQAM, C.P. 8888, Succ Centre-Ville, Montreal, Quebec H3C3P8, Canada. *$SL_k$-Tilings of Lattices.* Preliminary report.

We present general results on (bi-infinite) arrays having all adjacent $k \times k$ adjacent minors equal to one. In particular, we consider the situation when these arrays are of minimal rank, describing how to construct them all. Several intriguing new properties are made apparent, and ties with $T$-systems of statistical physics, cluster algebras, and frieze patterns of Conway-Coxeter will be outlined. (Received September 16, 2009)

1056-05-706 **David R Prier*** (prierdr@auburn.edu), 302 Shelton Mill Rd., Auburn, AL 36830, and **Peter D Johnson** (johnspd@auburn.edu), 221 Parker Hall, Auburn University, AL 36849-5310. *Graphs in which each independent dominating set intersects each minimum dominating set.*

Every graph with an isolated vertex has the property given in the title. Let such a graph with no isolated vertices be called DI-pathological, for short. Previously it was discovered that the only DI-pathological graphs with domination number no greater than 2 are the complete bipartite graphs K(m,n) with m,n $> 2$. Here we describe a large class of DI-pathological connected graphs, and prove that the smallest connected DI-pathological graph with domination number 3 consists of two 4-cycles joined by a path of length 2. (Received September 16, 2009)

1056-05-715 **Shanzhen Gao*** (sgao2@fau.edu), Department of Mathematics, Florida Atlantic University, 777 Galdes Road, Boca Raton, FL 33431. *Enumeration Of Bipartite Graphs.*

How many 4 times 8 (0,1)-matrices are there with four 1's in every row and two 1's in every column? (This is also the number of labeled bipartite graphs of a certain type.). We'll look at this question for m times n matrices required to have s ones in every row and t ones in every column. A formula is given for m=n and s=t=3 in R.Stanley's "Enumerative Combinatorics". We will present some closed formulas this question, for example, s=3, and any t. (Received September 16, 2009)

1056-05-723 **H. A. Kierstead** and **A. V. Kostochka*** (kostochk@math.uiuc.edu), Dept of Mathematics, 1409 W. Green Street, Urbana, IL 61801. *Equitable list coloring of graphs with low maximum degree.* Preliminary report.

If every vertex $v$ of a graph $G$ is given a list $L(v)$ of admissible colors, then an *$L$-coloring of $G$* is any proper coloring $f$ of $V(G)$ such that $f(v) \in L(v)$ for every $v \in V(G)$. If the lists all have size $k$, then an $L$-coloring is *equitable* if each color appears on at most $\lceil n(G)/k \rceil$ vertices. A graph is *equitably $k$-choosable* if such $L$-coloring exists whenever $|L(v)| = k$ for every $v \in V(G)$.

Kostochka, Pelsmajer and West in 2003 conjectured that every graph with maximum degree at most $r$ is equitably $(1+r)$-choosable. If true, this would generalize the Hajnal-Szemerédi Theorem. It is evident for $r \leq 2$. Pelsmajer and independently Lih and Wang confirmed the conjecture for $r = 3$. Also, Pelsmajer proved that every graph with maximum degree at most $r$ is equitably $(2 + \frac{r(r-1)}{2}$-choosable, and Lih and Wang proved that every such graph is equitably $(r-1)^2$-choosable.

For several reasons, the techniques previously used for ordinary equitable colorings are insufficient to handle equitable choosability. We introduce some improvements that allow us to prove that the conjecture holds for all $r \leq 7$, and that every graph with maximum degree at most $r \geq 3$ is equitably $2r$-choosable. (Received September 16, 2009)

1056-05-731 **Yanting Liang*** (lyt814@math.wvu.edu), Department of Mathematics, West Virginia University, Morgantown, WV 26506. *Supereulerian Graphs and Hamiltonian Line Graphs.*

Boesch, Suffel, and Tindell in [1977 JGT] proposed the problem to characterize supereulerian graphs, which are the graphs containing spanning Eulerian subgraphs. Pulleyblank in [1979 JGT] showed that determining if a graph is supereulerian is NP-complete. Catlin and Li in [1999 J. Adv. Math.] are the first pioneers who consider the problem of characterizing supereulerian graphs in the family $C_h(l,k)$. We prove that for any integer $k > 0$, there exists an integer $N = N(k)$ such that for any $n \geq N$, any graph $G \in C_2(6,k)$ on $n$ vertices is supereulerian if and only if $G$ cannot be contracted to a member in a well characterized family of graphs. Supereulerian graphs have been also studied and applied to investigate hamiltonian line graphs. A graph $G$ is $s$-hamiltonian-connected if the deletion of any vertex subset with at most $s$ vertices results in a hamiltonian-connected graph. We proved that the line graph of a $(t+4)$-edge-connected graph is $(t+2)$-hamiltonian-connected if and only if it is $(t+5)$-connected, and for $s \geq 2$ every $(s+5)$-connected line graph is $s$-hamiltonian-connected in [2008 DM]. (Received September 16, 2009)

1056-05-760 **Nathan Kahl*** (Nathan.Kahl@shu.edu), Dept. of Mathematics and Computer Science, Seton Hall University, 400 S. Orange Ave., South Orange, NJ 07079, and **Douglas Bauer**, **Hajo Broersma**, **Ed Schmeichel** and **Jan van den Heuvel**. *Toughness and Degree Sequence Conditions.* Preliminary report.

We examine conditions on the degree sequence of a graph $G$ that guarantee that $G$ is at least $t$-tough, for some $t > 0$. Most degree sequence theorems guaranteeing $G$ has some graphical property (e.g. hamiltonicity, $k$-connectedness) are monotone, meaning when a degree sequence satisfies the condition of the theorem, then any 'larger' degree sequence does too. For $t \geq 1$ we give a monotone theorem for a graph to be $t$-tough, and show that it is the best possible monotone theorem. On the other hand, we show that when $r \geq 1$, then a best monotone theorem for $t = \frac{1}{r} < 1$ requires at least $f(r)|V(G)|$ nonredundant conditions, where $f(r)$ grows superpolynomially as $r \to \infty$. (Received September 16, 2009)

1056-05-795 **Sarah K Merz*** (smerz@pacific.edu), Department of Mathematics, University of the Pacific, Stockton, CA 95211, and **Kim A.S. Factor**. *The $(1,2)$-step competition graph of a tournament.*

The competition graph of a digraph, introduced by Cohen in 1968, has been extensively studied. More recently, in 2000, Cho, Kim, and Nam defined the $m$-step competition graph. In this talk, we offer another generalization of the competition graph. We define the $(1,2)$-step competition graph of a digraph $D$, denoted $C_{1,2}(D)$, as the graph on $V(D)$ where $\{x,y\} \in E(C_{1,2}D)$ if and only if there exists a vertex $z \neq x,y$, such that either $dist_{D-y}(x,z) = 1$ and $dist_{D-x}(y,z) \leq 2$ or $dist_{D-x}(y,z) = 1$ and $dist_{D-y}(x,z) \leq 2$. In this talk, we characterize the $(1,2)$-step competition graph of tournaments and extend our results to the $(i,j)$-step competition graph of a tournament. (Received September 17, 2009)

1056-05-838 **Lale Özkahya*** (ozkahya@illinois.edu). *On extremal cycle-free subgraphs of the hypercube.*

Erdös conjectured that the size of the extremal 4-cycle-free subgraph of the n-dimensional hypercube, $ex(Q_n, C_4)$, is $(0.5+o(1))e(Q_n)$, where $e(Q_n)$ is the number of edges of the n-dimensional hypercube. We consider the general Turan problem on $Q_n$ for cycles of length $4k+2$, $k \geq 3$, and show that $ex(Q_n, C_{4k+2})$ is $o(1)e(Q_n)$. This is joint work with Zoltán Füredi. (Received September 17, 2009)

1056-05-898 **Hao Li*** (hli@math.wvu.edu), 320 Armstrong Hall, P.O. Box 6310, Morgantown, WV 26505. *Group Colorability of Graphs.*

Group coloring was first introduced by Jeager et al. [J. Combin. Theory Series B, (1992)]. They introduced a concept of group connectivity as a generalization of nowhere zero flows and its dual concept group coloring. In this paper, we investigated the properties of group colorability of graphs, especially for complete bipartite graphs. We also extended group coloring to multi-graphs. Upper bounds of group chromatic number for multi-graphs were given out, especially for $K_5$-minor free graphs and $K_{3,3}$-minor free graphs. (Received September 18, 2009)

1056-05-903 **Lon H Mitchell***, Department of Mathematics, Virginia Commonwealth University, PO Box 842014, Richmond, VA, and **Sivaram K Narayan** and **Andy Zimmer**. *Lower bounds in minimum rank problems.*

The minimum rank of a graph is the smallest possible rank among all real symmetric matrices with the given graph. The minimum semidefinite rank of a graph is the minimum rank among Hermitian positive semidefinite matrices with the given graph. We explore connections between OS-sets and a lower bound for minimum rank related to zero forcing sets as well as exhibit graphs for which the difference between the minimum semidefinite rank and these lower bounds can be arbitrarily large. (Received September 18, 2009)

1056-05-905 **John H. Johnson*** (john.j.jr@gmail.com). *C-sets in an uncountable semigroup.* Preliminary report.

A linear homogeneous system of equations (with rational coefficients) is called *partition regular* if whenever the natural numbers are partitioned into finitely many classes, at least one of the cells contains a solution to the system. Central subsets of $\mathbb{N}$ contains solutions to every partition regular linear homogeneous system. This particular result follows from the Central Sets Theorem. Central sets and the Central Sets Theorem have been generalized to arbitrary semigroups. In order better to focus on the consequences of the Central Sets Theorem, the point-of-view is shifted to $C$-sets. $C$-sets are sets that satisfy the conclusion of the Central Sets Theorem. Hindman and Strauss recently obtained three simple characterizations of $C$-sets. With the additional assumption that the underlying semigroup is countable, they proved four characterizations. This talk will show that this countability assumption cannot be dropped. (Received September 18, 2009)

1056-05-910 **Tricia Muldoon Brown*** (tricia.muldoon.brown@gmail.com), Department of Mathematics, Armstrong Atlantic State University, 11935 Abercorn Street, Savannah, GA 31419, and **Margaret Readdy** (readdy@ms.uky.edu), Department of Mathematics, 714 Patterson Office Tower, University of Kentucky, Lexington, KY 40506. *The Rees Product with a Poset or its Dual Poset.*

The Rees product is a poset product defined by Björner and Welker to model a particular case of the commutative algebra version of the Rees algebra. As an example we consider the Rees product of the cubical lattice with a chain. We observe that the Möbius values of this poset are equal to the Möbius values of the Rees product of the dual of the cubical lattice with a chain. We prove that this is true in general for graded posets, and further we show that the Möbius function of the Rees product of a graded poset with the $t$-ary tree and the Rees product of its dual with the $t$-ary tree also coincide. (Received September 18, 2009)

1056-05-912 **Akalu Tefera*** (teferaa@gvsu.edu), Grand Valley State University, Department of Mathematics, Allendale, MI 49401, and **Aklilu Zeleke** and **George Grossman**. *Combinatorial Proofs of Certain Identities.*

We present combinatorial proofs of interesting identities that arise in the study of zeros of the j-th order polynomial of the generalized Fibonacci sequence. (Received September 18, 2009)

1056-05-914 **Brant C. Jones*** (brant@math.ucdavis.edu). *An explicit derivation of the Möbius function for Bruhat order.*

We give an explicit non-recursive complete matching for the Hasse diagram of the strong Bruhat order of any interval in any Coxeter group. This yields a new derivation of the Möbius function, recovering a classical result due to Verma. The matching is given in terms of combinatorial objects called masks that arise in Deodhar's formula for the Kazhdan–Lusztig polynomials. (Received September 18, 2009)

1056-05-932 **Miklos Bona*** (bona@ufl.edu), Department of Mathematics, University of Florida, Gainesville, FL 32611-8105. *The absence of a given pattern and the number of occurrences of another.*

Following a question of J. Cooper, we study the expected number of occurrences of a given permutation pattern $q$ in permutations that avoid another given pattern $r$. In some cases, we find the pattern that occurs least often, (resp. most often) in all $r$-avoiding permutations.We also prove a few exact enumeration formulae, some of which are surprising. Several open questions and conjectures will be announced. (Received September 18, 2009)

1056-05-949 **Jeffrey E Liese*** (jliese@calpoly.edu). *The distributions of $k$-drops and $k$-excedences in permutations.*

Given a permutation $\sigma = \sigma_1 \dots \sigma_n$ in the symmetric group $S_n$, we say that $\sigma$ has a $k$-drop at $i$ if $\sigma_i - \sigma_{i+1} = k$ and $\sigma$ has a $k$-excedence at $i$ if $\sigma_i - i = k$. The bijection due to Foata which shows that the distribution of descents in permutations in $S_n$ equals the distribution of excedences in $S_n$ also shows that the distribution of $k$-drops in $S_n$ is equal to the distribution of $k$-excedences in $S_n$.

This talk will focus on the distribution of $k$-drops and $k$-excedences in $S_n$, including explicit formulas as well as generating functions. The work in this area is a lovely generalization of many classic results on derangements and a majority of these results can be proven purely combinatorially. (Received September 18, 2009)

1056-05-955 **Reza Zamani** (zamani@illinois.edu), Computer Science Dept., University of Illinois, Urbana, IL 61801, and **Douglas B. West*** (west@math.uiuc.edu), Mathematics Dept., University of Illinois, Urbana, IL 61801. *Spanning cycles through specified edges in bipartite graphs.*

Pósa proved that if $G$ is an $n$-vertex graph in which any two nonadjacent vertices have degree sum at least $n+k$, then $G$ has a spanning cycle containing any specified family of disjoint paths with a total of $k$ edges. We consider the analogous problem for a bipartite graph $G$ with $n$ vertices and parts of equal size. Let $F$ be a subgraph of $G$ whose components are nontrivial paths. Let $k$ be the number of edges in $F$, and let $t_1$ and $t_2$ be the numbers of components of $F$ having odd and even length, respectively. For $n \geq 9k+4$, there is a spanning cycle in $G$ containing $F$ if any two nonadjacent vertices in opposite partite sets have degree-sum at least $n/2+\tau(F)$, where $\tau(F) = \lceil k/2 \rceil + \epsilon$ (here $\epsilon = 1$ if $t_1 = 0$ or if $(t_1, t_2) \in \{(1,0),(2,0)\}$, and $\epsilon = 0$ otherwise). The threshold on the degree-sum is sharp. (Received September 18, 2009)

1056-05-963 **Ruth Haas*** (rhaas@smith.edu), Department of Mathematics and Statistics, Smith College, Northampton, MA 01063. *The Canonical Coloring Graph.*

Given a graph $G$, a Canonical Coloring Graph $Can(G)$ has vertex set the set of all nonisomorphic colorings of the graph $G$, where the representative of each set of isomorphic colorings are chosen according to a canonical ordering. There is an edge between two colorings if they are identical on $V(G-x)$ for some $x \in V(G)$. $Can(G)$ varies depending on the choice of canonical representatives. In this talk we give recent results about properties of $Can(G)$. (Received September 19, 2009)

1056-05-979 **Jacob N Steinhardt*** (jsteinha@mit.edu), 282 Massachusetts Avenue, Room 425s, Cambridge, MA 02139. *Permutations with Ascending and Descending Blocks.*

I will present a bijection due to Gessel and Reutenauer between permutations that ascend in blocks of prescribed lengths and multisets of necklaces with certain properties. This bijection was first used to provide an enumeration of permutations with given descent set and cycle structure. I will then present a generalization of the Gessel-Reutenauer bijection to permutations with both ascending and descending blocks. (Received September 19, 2009)

1056-05-992 **Gregory B Hurst*** (ghurst2@illinois.edu), 808 Coventry Point, Springfield, IL 62702. *An elementary proof of Touchard's Congruence.*

The $n$th Bell number, denoted $B_n$, is the number of ways a set of $n$ elements can be partitioned into nonempty subsets. It is easy to see that $B_n$ is the sum of $S(n,k)$ where $k$ ranges from 1 to $n$ and $S(n,k)$ is the number of ways to partition a set of $n$ elements into $k$ nonempty subsets. We will consider a formula for the $n+j$th Bell number which has just been discovered in the last two years. This formula states that $B_{n+j}$ is the sum of $S(n,k)$ times a polynomial of degree $j$. This polynomial, denoted $P_j(k)$, also satisfies the recurrence relation $P_{j+1}(k) = P_j(k+1)+kP_j(k)$ with base case $P_0(k) = 1$. Using this formula for $B_{n+j}$, relations such as Touchard's congruence:

$$B_{n+p^r} \equiv B_{n+1} + rB_n \mod p$$

where $p$ is prime, can be proven elementarily. (Received September 19, 2009)

1056-05-997 **Timothy L Vis*** (Timothy.Vis@ucdenver.edu), Department of Math. and Stat. Sciences, Campus Box 170, PO Box 173364, Denver, CO 80217-3364. *Generalized Oval Derivation.*

We generalize techniques of Basile and Brutti (1979) and Assmus and Key (1990) that replace lines in an affine plane with ovals to produce another affine plane. In particular, we show that the derivation techniques can be applied to structures much more general than ovals without weakening any of the results. We also show that the planes obtained through these techniques are always isomorphic to the original planes, answering in the negative a question left open in Assmus and Key. We classify a group of collineations inherited through the derivation procedure that is always either the full group of such collineations or, under certain circumstances, an index two subgroup of the full group of such collineations. We finally describe the derivation procedure as a map on the points of the planes with the aim of understanding relationships between different structures in the affine plane under investigation. (Received September 21, 2009)

1056-05-1043 **Vahid Tarokh*** (vahid@seas.harvard.edu), 33 Oxford University, Room MD 347, Harvard University–SEAS, Cambridge, MA 02139, and **Maryam Sabbaghian**, **Besma Smida** and **Yongjun Kwak**. *Near Shannon limit low Peak to Average Power Ratio Turbo Block Coded OFDM.*

In this talk, we present an advanced solution for the long standing problem of large peak to average power ratio in orthogonal frequency division multiplexing (OFDM) systems. Although the design of low PAPR codewords has been extensively studied and the existence of asymptotically good codes with low PAPR is also proven, still no code has been constructed to satisfy all requirements. The main goal of this talk is to disclose a coding scheme that not only generates low peak to average power ratio (PAPR) codewords, but it also performs as close as possible to the Shannon limit. We achieve this goal by implementing a time-frequency turbo block coded OFDM. In this two dimensional turbo block code, we design the frequency component to have a tightly bounded PAPR. The time domain component code is designed to obtain good performance while the decoding algorithm has reasonable complexity. Through comparative performance evaluation we show that utilizing the proposed scheme, we achieve considerable improvement in terms of PAPR while we slightly loose the performance compared to other powerful coding methods such as convolutional based turbo codes or low density parity check (LDPC) codes with similar block length. (Received September 20, 2009)

1056-05-1063 **Michael Albertson**, **Debra Boutin*** (dboutin@hamilton.edu) and **Ellen Gethner**. *The thickness and chromatic number of r-inflated graphs.*

Catlin's graphs are the lexicographic product of a cycle $C_n$ with a complete graph $K_r$; another name for this is the *r-inflation of* $C_n$ which we denote $C_n[r]$. The sets $\{C_n[2]\}$ and $\{C_n[3]\}$ are infinite graph families having the unusual property that both the chromatic number and thickness are known for each member. This talk expands on this idea by considering the thickness and chromatic number of the $r$-inflation of other graphs. (Received September 20, 2009)

1056-05-1075 **Eunjeong Yi*** (yie@tamug.edu), Texas A&M University at Galveston, P.O. Box 1675, Galveston, TX 77553. *Coding Sequences and Their Applications.* Preliminary report.

For any graph $G$ with vertices given by positive integers $1, 2, \ldots, n$, a *pseudo-coding sequence* of $G$ is an ordered listing of the vertices where each edge is represented by exactly one pair of consecutively-listed vertices and where a lifting of the pen is denoted by the number 0. If a pseudo-coding sequence contains the minimum number of zeros, it is called a *coding sequence* of $G$. Coding sequences can be a useful device for the storage and the communication of graphs. In this talk, we discuss new invariants of graphs arising out of coding sequences. For applications, first we give a new proof of Euler's formula for connected planar graphs; then we give either formulas or algorithms of coding sequences for complete graphs. We also plan to discuss the applications of coding sequences to Paley graphs. (Received September 20, 2009)

1056-05-1077 **Greta Panova*** (panova@math.harvard.edu), One Oxford St Rm 431h, Cambridge, MA 02138. *Bijective enumeration of permutations starting with a longest increasing subsequence.*

We give a bijective proof of an inclusion-exclusion type formula for $\#\Pi_{n,k}$, the set of permutations in $S_n$ whose first $n-k$ elements are increasing and whose largest increasing subsequence has length exactly $n-k$. We exhibit two bijective proofs, one involving the RSK correspondence and another involving only permutations. Both approaches give direct rise to a $q-$analogue of the enumeration formula with statistic the major indices of the inverse permutations of $\Pi_{n,k}$. This problem originated in the recent research of Adriano Garsia and a \$ 100 prize was offered for its bijective proof, awarded to the author. (Received September 20, 2009)

1056-05-1097 **Louis DeBiasio*** (louis@mathpost.asu.edu), Arizona State University, Tempe, AZ 85287, and **Andrzej Czygrinow** and **H. A. Kierstead**. *A degree condition for spanning cycles in bipartite graphs.*

Let $G = (U, V; E)$ be a bipartite graph on $2n$ vertices such that $|U| = n = |V|$ and $\deg(u) + \deg(v) \geq n + k$ for all $u \in U$, $v \in V$. In his work on Hamiltonian bipartite graphs, Amar conjectured that if $H$ is a set of $k$ even cycles on a total of $2n$ vertices, then $H$ is a subgraph of $G$. We prove this conjecture for large $n$. Furthermore, we prove that $H$ is a subgraph of $G$ even when $\deg(u) + \deg(v) \geq n + 2$ for all $u \in U$, $v \in V$, provided the minimum degree of $G$ is not too small. (Received September 20, 2009)

1056-05-1113 **Adam C Hesterberg*** (ahesterb@princeton.edu), 4342 Frist Center, Princeton, NJ 08544. *Extremal functions of excluded block permutation matrices.*

For a 0-1 matrix $P$, $ex(n, P)$ is the maximum number of ones in an $n \times n$ matrix that cannot be reduced to $P$ by deleting some rows and columns and changing some 1s to 0s. We show that if $P$ is a permutation matrix and $Q$ is arbitrary, then the order of growth of $ex(n, P \otimes Q)$ is the same as that of $ex(n, Q)$ (up to, in some cases, a factor of $n^{\epsilon}$), extending a result used in the proof of the Stanley-Wilf conjecture. (Received September 20, 2009)

1056-05-1139 **Darren A Narayan*** (dansma@rit.edu), School of Mathematical Sciences, 85 Lomb Memorial Drive, Rochester Institute of Technology, Rochester, NY 14623-5604.
*Intermediate Ordered Colorings of Graphs.*

Given a graph $G$, a function $f : V(G) \rightarrow \{1, 2, ..., k\}$ is an ordered coloring or $k$-ranking of $G$ if $f(u) = f(v)$ implies every $u - v$ path contains a vertex $w$ such that $f(w) > f(u)$. A $k$-ranking is minimal if the reduction of any label greater than 1 violates the described ranking property. The rank number of a graph, denoted $\chi_r(G)$, is the minimum $k$ such that $G$ has a minimal $k$-ranking. The arank number of a graph, denoted $\psi_r(G)$, is the maximum $k$ such that $G$ has a minimal $k$-ranking. It was asked by Laskar, Pillone, Eyabi, and Jacob if there is a family of graphs where minimal $k$-rankings exist for all $\chi_r(G) \leq k \leq \psi_r(G)$. We given an affirmative response to their question showing that all intermediate minimal $k$-rankings exist for all paths, cycles, and $K_{n_1,n_2,...,}K_{n_p}$ where $n_{i+1} = n_i - 1$ for all $1 \leq i \leq p - 1$. (Received September 22, 2009)

1056-05-1146 **Sebastian M Cioabă*** (cioaba@math.udel.edu), Department of Mathematical Sciences, Newark, DE 19713. *Decompositions of graphs and hypergraphs.*

In 1971, Graham and Pollak proved the minimum number of complete bipartite subgraphs that partition the edge-set of the complete graph on n vertices, is n-1. In 1986, Alon extended Graham-Pollak Theorem to uniform hypergraphs. I will present some improvements of Alon's result and I will list some related open problems. This is joint work with André Kündgen (Cal State, San Marcos) and Jacques Verstraëte (UC-San Diego). (Received September 21, 2009)

1056-05-1212 **William Chen**, **Svetlana Poznanović*** (spoznan@math.tamu.edu), **Catherine Yan** and **Arthur Yang**. *Major Index for 01-Fillings of Moon Polyominoes.*

We propose a major index statistic on 01-fillings of moon polyominoes which, when specialized to certain shapes, reduces to the classical major index for permutations and set partitions. We consider the set $\mathbf{F}(\mathcal{M}, \mathbf{s}; A)$ of all 01-fillings of a moon polyomino $\mathcal{M}$ with given column sum $\mathbf{s}$ whose empty rows are $A$, and prove that this major index has the same distribution as the number of north-east chains, which are the natural extension of inversions (resp. crossings) for permutations (resp. set partitions). Hence our result generalizes the classical equidistribution results for the permutation statistics inv and maj. Two proofs will be presented. The first is an algebraic one using generating functions, and the second is a bijection on 01-fillings of moon polyominoes in the spirit of Foata's second fundamental transformation on words and permutations. (Received September 21, 2009)

1056-05-1245 **Karen L. Collins*** (kcollins@wesleyan.edu), Dept. of Mathematics and Computer Science, Exley Science Center, Wesleyan University, Middletown, CT 06459-0128.
*Distinguishing with Mike Albertson.*

The distinguishing number of a graph was first defined by Mike Albertson and the presenter in 1996, and the distinguishing chromatic number was first defined by the presenter and Ann Trenk in 2006. This talk will compare and contrast known results about each parameter from the point of view of how the automorphism group of a graph affects its distinguishing and distinguishing chromatic numbers, with particular emphasis on the contributions of Mike Albertson. (Received September 21, 2009)

1056-05-1254 **Maria Axenovich*** (axenovic@iastate.edu), 412 Carver Hall, Ames, IA 50011, and **Jacob Manske** and **Ryan Martin**. *On extremal problems in a Boolean lattice.* Preliminary report.

Let $P$ be a fixed subposet of a Boolean lattice. Let the maximal number of elements in a Boolean lattice $Q_n$ that induce a subposet containing no copy of $P$ be $ex(n, P)$. Denote the size of a middle layer of $Q_n$ by $N$.

The classical Sperner theorem states that $ex(n, P_2) = N$, where $P_2$ is a two element chain. There are several other examples of posets for which the extremal function has been calculated asymptotically. In all of these known cases $ex(n, P) = iN(1 + o(1))$, where $i$ is an integer. It has been conjectured that the extremal function is always an integer multiple of the middle layer size.

The only poset with at most 4 elements for which this conjecture is not confirmed is $Q_2$. We provide improved bounds on $ex(n, Q_2)$ and show the limitation of classical methods applied to this problem. (Received September 21, 2009)

1056-05-1273 **Allan Edward Bickle*** (allan.e.bickle@wmich.edu), Kalamazoo, MI 49009. *Ramsey Core Numbers.* Preliminary report.

The k-core of a graph is the maximal subgraph of a graph with minimum degree at least k. A natural generalization of Ramsey numbers is the Ramsey core number rc(s,t), which is the least order n necessary to guarantee that every graph of order n contains an s-core or its complement contains a t-core. We determine a good upper bound for these numbers, which is conjectured to be exact. We also determine some exact values for Ramsey core numbers, both for infinite classes and isolated cases. (Received September 21, 2009)

1056-05-1275 **Thomas Langley*** (langley@rose-hulman.edu), Rose-Hulman Institute of Technology, Department of Mathematics, CM144, 5500 Wabash Ave., Terre Haute, IN 47803, and **Jeffrey Liese** (jliese@calpoly.edu) and **Jeffrey Remmel** (remmel@math.ucsd.edu). *Wilf equivalence for generalized factor order modulo k.*

Kitaev, Liese, Remmel and Sagan recently defined generalized factor order on words with letters from a poset $(P, \leq_P)$ by setting $u \leq_P w$ if there is an embedding of $u$ into $w$. If $P$ is the positive integers with the usual ordering, they defined the weight of a word $u = u_1 \ldots u_n$ to be $\mathrm{wt}(u) = x^{\sum_{i=1}^{n} u_i} t^n$ and introduced the weight generating function $F(u; t, x) = \sum_{w \geq_P u} \mathrm{wt}(w)$. They defined two words $u$ and $v$ to be Wilf equivalent if and only if $F(u; t, x) = F(v; t, x)$, and provided combinatorial proofs of many Wilf equivalences. We continue this study by giving an explicit formula for a related generating function in the event that $u$ has a certain factorization, allowing us to classify Wilf equivalence for all words of length 3. We then extend Kitaev, Liese, Remmel and Sagan's ideas to the poset $\mathcal{P}_k$, defined as the positive integers with the ordering $i <_k j$ if $i < j$ and $i \equiv j \mod k$ for $k \geq 2$, providing many analogues of their results in this new setting. We also give an analogue of our generating function formula, valid for a rich class of words, and classify Wilf equivalence for permutations of $n$ with $n \leq 2k$, and for all words of length 3 in this context. (Received September 21, 2009)

1056-05-1277 **Deborah A Chun*** (dchun@math.lsu.edu), 303 Lockett Hall, Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803-4918. *Elements in unavoidable minors of 3-connected binary matroids.* Preliminary report.

Ding, Operowski, Oxley, and Vertigan proved that every sufficiently large 3-connected, binary matroid has as a minor a large binary spike, or, for a large $n$, the cycle or bond matroid of an $n$-spoked wheel or $K_{3,n}$. We discuss what can be said when one seeks to keep a specified element in one of the special minors. (Received September 21, 2009)

1056-05-1281 **Nathan Axvig*** (s-naxvig1@math.unl.edu), 203 Avery Hall, 880130, Lincoln, NE 68588-0130. *Characterizing linear programming pseudocodewords using graphical methods.*

The linear programming decoder, as defined by Feldman, is a relaxation of the maximum-likelihood integer program for binary linear codes. Central to the study of this decoder is its corresponding fundamental polytope, the feasible region over which the optimization takes place. The linear programming decoder is suboptimal when compared to maximum-likelihood decoding, and the loss in performance can be credited to the presence of non-integral extreme points (vertices) of the fundamental polytope, also referred to as linear programming pseudocodewords.

For the special class of cycle codes, we obtain a characterization of these fractional extreme points in terms of information taken from the associated Tanner graph. This characterization allows for easy identification and construction of pseudocodewords, and the techniques used in its proof may shed light on how to obtain a result for the general case. (Received September 21, 2009)

1056-05-1315 **Elizabeth Moseman*** (lizz.moseman@gmail.com), West Point, NY 10996, and **Chris Storm**. *Forbidden Subgraphs in Oriented Line Graphs.*

Kotani and Sunada introduced the oriented line graph as a tool in the study of the Ihara zeta function of a finite graph. The spectral properties of the adjacency operator on the oriented line graph can be linked to the Ramanujan condition of the graph. In this talk, a reverse construction is given, to find the original graph from which an oriented line graph arises. This construction gives rise to three families of graphs which cannot occur as a subgraph of an oriented line graph. (Received September 21, 2009)

1056-05-1319 **Tariq Akef Alraqad*** (tariq.alraqad@northern.edu), 1200 South Jay street, Northern State University, Department of Math & Science, Aberdeen, SD 57401, and **Mohan Shrikhande** (mohan.shrikhande@cmich.edu), Department of Mathematics, Central Michigan University, Mt. Pleasant, MI 48859. *Some Results On $\lambda$-Designs With Two Block Sizes.* Preliminary report.

A $\lambda$-design is a family $\mathcal{B} = \{B_1, B_2, \cdots, B_v\}$ of subsets of $X = \{1, 2, \ldots, v\}$ such that $|B_i \cap B_j| = \lambda$ for all $i \neq j$ and not all $B_i$ are of the same size. The only known example of $\lambda$-designs (called type-1 designs) are those obtained from symmetric designs by a certain complementation procedure. Ryser and Woodall independently conjectured that all $\lambda$-designs are type-1. In this paper, we consider $\lambda$ designs with exactly two block sizes. Let $g = gcd(r-1, r^*-1)$, where $r$ and $r^*$ are the two replication numbers. We show that the Ryser-Woodall conjecture is true for all $\lambda$-designs with two block sizes and $g = 7$ or $9 \leq g \leq 18$. We also give two results on $\lambda$-designs with two block sizes on $v = 9p+1$ and $12p+1$ points, where $p$ is a prime. (Received September 21, 2009)

1056-05-1330 **Cassandra Naymie*** (cnaymie@gmail.com), 29 B Young St., Waterloo, ON V6K 1T8, **Charlie Suer** (suerchaj@gmail.com), 3131 Woodsfield St., Cincinnati, OH 45213, and **Erin Pitney** (epitney@mac.com). *Competitive Graph Coloring on Outerplanar Graphs.* Preliminary report.

Graph coloring games are games played on graphs between Alice and Bob. Alice is trying to color every vertex of the graph and Bob is trying to force an uncolored vertex. These games have been studied extensively, but there are still many unsolved problems. In this presentation we discuss an activation strategy for Alice to use on a certain subclass of outerplanar graphs. Using this strategy, we prove that for all graphs in this subclass, $\chi_{\rm g}(G) \leq 6$ and ${\chi^2}_{\rm g}(G) \leq 3$, where $\chi_{\rm g}(G)$ is the least number of colors Alice needs to win the original coloring game and ${\chi^2}_{\rm g}(G)$ is the least number of colors Alice needs to win the 2-clique relaxed coloring game. (Received September 22, 2009)

1056-05-1359 **Adam Goyt** and **Lara Pudwell*** (Lara.Pudwell@valpo.edu), Department of Mathematics & Computer Science, 1900 Chapel Drive, Valparaiso, IN 46383. *Avoiding Colored Partitions.* Preliminary report.

One challenging problem is counting pattern-avoiding set partitions. A set partition can be written in a uniform way if each block is written in increasing order, and the blocks are ordered by increasing minimal elements. With this convention, any set partition of $\{1, \ldots, n\}$ can be encoded as a string $s_1 \cdots s_n$ where $s_i = j$ if element $i$ lies in block $j$. It is easily seen that a partition is non-crossing if its string encoding avoids the pattern 1212. Further results involving pattern-avoiding set partitions were developed by Klazar, Sagan, and Goyt.

Motivated by recent results for pattern avoidance in colored permutations, we define the notion of pattern-avoiding colored partitions. A colored set partition is one where each number of the set partition is assigned one of $k$ colors. Given colored set partitions $P$ and $R$, let $P^*$ and $R^*$ be the underlying uncolored set partitions for $P$ and $R$ respectively. We say $P$ contains $R$ if $P^*$ contains $R^*$ as a subpartition, and if the colors on the subpartition equal those of $R$. Initial enumerative results will be provided as well as conjectured relationships to other combinatorial objects. (Received September 21, 2009)

1056-05-1361 **Sarah K Mason*** (sarahkmason@gmail.com), San Diego, CA , and **Aaron Lauve**. *A basis for the coinvariant space for quasisymmetric polynomials.* Preliminary report.

The coinvariant space for quasisymmetric polynomials is the quotient ring of quasisymmetric functions by symmetric functions. Garsia and Wallach used an algorithmic approach to prove that this ring has dimension n!, where n is the number of variables. In this joint work with Lauve, we affirm that the basis conjectured by Bergeron and Reutenauer is indeed a basis for this quotient ring, providing the first constructive proof of the Garsia-Wallach result. Our proof utilizes recent results (joint with Haglund, Luoto, and van Willigenburg) on the multiplication of quasisymmetric functions. (Received September 21, 2009)

1056-05-1371 **Mahir Bilen Can*** (mcan@tulane.edu), Mathematics Department, Tulane University, 6823 St. Charles Ave., New Orleans, LA 70118. *Some enumerative and order theoretic aspects of the rook monoid.*

In this talk we will be looking into enumerative and order theoretic properties of the rook monoid which is the inverse semigroup of $n \times n$ $0/1$ matrices with at most one 1 in each row and each column. We show that the rank function on matrices restricted to some subsemigroups of the rook monoid leads to the generating functions of important combinatorial sequences such as Eulerian numbers, Catalan numbers, Narayana numbers, etc.. We look into the extensions of the weak and the strong Bruhat orderings to the rook monoid. Furthermore, we investigate the embeddings of a symmetric group into a rook monoid as a Bruhat subposet (joint work with L.

Renner). If time permits using the monoid Hecke algebra and its Kazhdan-Lusztig polynomials we investigate the embeddings of the intervals of a rook monoid into a symmetric group (joint work with K. Aker). (Received September 21, 2009)

1056-05-1377 **Amy Mihnea*** (amalyamy@yahoo.com), 6121 Balboa Cir. Apt. 206, Boca Raton, FL 33433. *Using Analysis of Algorithms to Derive Combinatorial Equalities.*

Two algorithms are analyzed and compared and the results obtained lead to combinatorial formulas which we then prove. The first one finds the greatest and the second greatest element of an array and the second one finds the smallest and the second smallest element. We use permutations to analyze their behavior for all possible inputs. The algorithms and the combinatorial formulas derived from the two algorithms are different but their average behavior is similar. This helps us to develop some equalities which might be harder to obtain in other ways. In setting them up and in proving them we first analyze the outputs given by a program we created, in order to find patterns. This helps us to use other auxiliary formulas for proving them. (Received September 21, 2009)

1056-05-1386 **Eric Riedl*** (eriedl@nd.edu), 1340 California Ave., Falcon Heights, MN 55108. *Minimal Percolating Sets in Trees.*

Bootstrap percolation is the process on a graph where, given an initial infected set, vertices with at least $r$ infected neighbors are infected until no new vertices can be infected. A set percolates if it infects all the vertices of the graph, and a percolating set is minimal if no proper subset percolates. We consider bootstrap percolation on trees. We describe an $O(n)$ algorithm for computing the largest and smallest minimal percolating sets and find bounds on the sizes of smallest and largest minimal percolating sets. Moreover, we find a bound on the difference between the sizes of a largest and smallest minimal percolating set. (Received September 21, 2009)

1056-05-1391 **C McLeman** (cmcleman@willamette.edu), Willamette University, Department of Mathematics, 900 State Street, Salem, OR 97301, and **E M McNicholas*** (emcnicho@willamette.edu), Willamette University, Department of Mathematics, 900 State Street, Salem, OR 97301. *Spectra of Coronae.*

We compute the spectrum of the corona $G \circ H$ of two graphs, $G$ and $H$. In particular, we introduce a new invariant, the *coronal* of a graph, and show that the spectrum of $G \circ H$ is completely determined by the spectra of $G$ and $H$ and the coronal of $H$. We compute the coronals explicitly for several families of graphs, including regular graphs, complete $n$-partite graphs, and path graphs. Finally, we use the corona construction to generate many infinite families of pairs of cospectral graphs. (Received September 21, 2009)

1056-05-1424 **Paul W.T. Fijn*** (paul@ms.unimelb.edu.au), 2/653 Park Street, Brunswick, Victoria 3056. *Playing with Paths: An Introduction to Bijective Combinatorics.*

We introduce the field of Enumerative Combinatorics as applied to sets of paths on the square lattice. Key techniques and methods will be discussed, and their applications to several problems in the enumeration of lattice paths. In particular, pictorial bijections for some novel results will be used to illustrate the central ideas of enumerative combinatorics. Finally, we discuss the applicability of this work to areas as diverse as genetics, computer science and theoretical physics. (Received September 22, 2009)

1056-05-1465 **Lucas J. Rusnak*** (rusnak@math.binghamton.edu), Department of Mathematical Sciences, Binghamton University, Binghamton, NY 13902. *Oriented Incidence and a Generalization of Hypergraphs.*

This talk will introduce an incidence-based orientation scheme for hypergraphs which combinatorially model {0, +1, -1}-matrices. Topics discussed will include the introduction of new hypergraphic structures and operations, the decomposition of oriented hypergraphs into three families of varying degrees of "balance", and their relevance to the classification of the minimal column dependencies of {0, +1, -1}-matrices. (Received September 21, 2009)

1056-05-1466 **Jobby Jacob*** (jxjsma@rit.edu) and **Renu Laskar**. *Irreducible No-Hole $L(2,1)$ labelings of some classes of graphs.*

Let $G$ be a graph. A labeling $f : V(G) \to \{0, 1, \ldots, k\}$ of $G$ is an $L(2,1)$ labeling if $|f(u) - f(v)| \geq 2$ when $u$ and $v$ are adjacent in $G$, and $|f(u) - f(v)| \geq 1$ when $u$ and $v$ are at distance two in $G$. An $L(2,1)$ labeling $f$ is a no-hole $L(2,1)$ labeling if $f$ is onto. An $L(2,1)$ labeling is irreducible if reduction of any label to a smaller label violates the conditions of $L(2,1)$ labeling.

In this talk we will discuss some results regarding irreducible no-hole $L(2,1)$ labelings of some classes of graphs including Cartesian products. (Received September 21, 2009)

1056-05-1478 **sarah-marie belcastro*** (smbelcas@toroidalsnark.net) and **Michael Young**. *The Excess Range of Factorizations of Regular Graphs.* Preliminary report.

An *excessive factorization* of a regular graph $G$ is a set of 1-factors that covers all edges of $G$ without redundancy (that is, no subset also covers all edges of $G$). For $k$-regular $G$, the smallest possible number of 1-factors in an excessive factorization is $k$. Because there are no "extra" factors, we say that a graph with a 1-factorization has minimum *excess* zero. Note that when the $G$ is $(k+1)$-edge chromatic, the minimum excess is either positive or nonexistent (if there exists an edge contained in no 1-factor). We consider the possible excess numbers of regular graphs, and focus in this talk on regular graphs with both minimum and maximum excess equal to zero. (Received September 21, 2009)

1056-05-1494 **Carolyn B. Chun*** (Carolyn.Chun@msor.vuw.ac.nz), School of MSOR, PO Box 600, Wellington, 6140, New Zealand, and **Dillon Mayhew**, **Stefan van Zwam** and **Geoff Whittle**. *Fragility in Matroids.* Preliminary report.

For a matroid $M$ with a minor $N$, we say that $M$ is $N$-fragile if, for every element $e$ in the ground set of $M$, either $M/e$ or $M\backslash e$ does not contain $N$ as a minor. Understanding the structure of $N$-fragile matroids is necessary for thinking about Rota's conjecture. In this talk, we present a characterization of the binary, Fano-fragile matroids. (Received September 22, 2009)

1056-05-1511 **Phong Q Chau*** (phong.chau@asu.edu), Tempe, AZ. *Hamiltonian Square Cycle in Ore-type Graphs.*

A square cycle is the graph obtained from a cycle by joining every pair of vertices of distance two in the cycle. A classical Theorem of Dirac asserts that every graph with minimum degree at least $n/2$ contains a hamiltonian cycle. As a generalization of Dirac's theorem, Pósa conjectured that every graph with minimum degree at least $2n/3$ contains a hamiltonian square cycle. Komlós, Sárközy and Szemerédi used the Regularity Lemma of Szemerédi and their own Blow-up Lemma to verify the truth of this conjecture for hugh graphs. In this talk, we consider an Ore-type version of Pósa's conjecture. We prove that if $G$ is a graph on $n$ vertices such that $\deg(u) + \deg(v) \geq 4n/3 - 1/3$ for all non-adjacent vertices $u$ and $v$, then for sufficiently large $n$, $G$ contains a hamiltonian square cycle unless its minimum degree is exactly $n/3 + 2$ or $n/3 + 5/3$. We also discuss three extremal examples showing that all conditions in the theorm are tight. (Received September 22, 2009)

1056-05-1512 **Ira M. Gessel*** (gessel@brandeis.edu), Department of Mathematics, MS 050, Brandeis University, Waltham, MA 02453-2728. *Flag descents and P-partitions.*

A *signed permutation* of $[n] = \{1, 2, \ldots, n\}$ is a sequence $a_1a_2\cdots a_n$ of integers such that $|a_1||a_2|\cdots|a_n|$ is a permutation of $[n]$. Let $B_n$ denote the set of signed permutations of $[n]$. In 2001, Adin, Brenti, and Roichman introduced the *flag-descent* statistic on signed permutations: for $\pi \in B_n$ we define $\operatorname{fdes}(\pi)$ to be $2\operatorname{des}(\pi) + \epsilon(\pi)$, where $\operatorname{des}(a_1a_2\cdots a_n)$ is the number of $i \in [n-1]$ for which $a_i > a_{i+1}$, and $\epsilon(a_1a_2\cdots a_n)$ is 1 if $a_1 < 0$ and 0 if $a_1 > 0$. Adin, Brenti, and Roichman proved that

$$\sum_{k=0}^{\infty}(k+1)^n t^k = \frac{\sum_{\pi\in B_n} t^{\operatorname{fdes}(\pi)}}{(1-t)(1-t^2)^n}.$$

I will explain how Richard Stanley's theory of P-partitions can be used to prove this and related formulas. (Received September 22, 2009)

1056-05-1519 **Vikram M Kamat*** (vikram.kamat@asu.edu), 1019 E. University Dr. Apt. 201, Tempe, AZ 85281, and **Glenn Hurlbert**. *A graph-theoretic generalization of the Erdös-Ko-Rado theorem.*

One of the more recent generalizations of the Erdös-Ko-Rado theorem, formulated by Holroyd, Spencer and Talbot, defines the Erdös-Ko-Rado property for graphs in the following manner: for a graph G and a positive integer r, G is said to be r-EKR if no intersecting subfamily of the family of all independent vertex sets of size r is larger than the largest star, where a star centered at a vertex v is the family of all independent sets of size r containing v. Let $\mu = \mu(G)$ be the minimum size of a maximal independent set in G. Among other results, we prove that if G is a disjoint union of chordal graphs with at least one isolated vertex, then G is r-EKR whenever $r \leq \mu/2$. (Received September 22, 2009)

1056-05-1545 **Timothy D. Ferdinands*** (tdf3@students.calvin.edu), 2725 Ardmore SE, Grand Rapids, MI 49506. *Proving Summation Identities: The WZ Method versus Counting.*

Discovering and proving summation identities has always intrigued mathematicians. There are many different techniques for proving such identities. Two of the most effective techniques are the WZ Method and the Counting Technique. The WZ method is a computer-based technique developed by Herbert Wilf and Doron Zeilberger in the early 1990s. The Counting Technique is one of the oldest known methods for proving summation identities. This talk will introduce each of these methods and demonstrate the effectiveness of each one. This is joint work with Samantha Dahlberg. (Received September 22, 2009)

1056-05-1551 **Walter Stromquist*** (mail@walterstromquist.com), 132 Bodine Road, Berwyn, PA 19312-1027. *Looking for a new proof of the Four Color Theorem.* Preliminary report.

This is a report on a partial proof of the Four Color Theorem that offers some hope, if it can be completed, of being simpler than the existing proofs. The main ideas are (1) a reducibility conjecture, that a certain easily testable characteristic of a configuration implies that it is D-reducible; and (2) a relatively uniform counting argument that does the work of the usual discharging procedure. This is very much a work in progress, and comments will be welcome. (Received September 22, 2009)

1056-05-1578 **Sami H Assaf*** (sassaf@math.mit.edu), MIT Department of Mathematics, 77 Massachusetts Ave, Cambridge, MA 02139, and **Peter R.W. McNamara**. *A Pieri rule for skew Schur functiond.*

The Pieri rule expresses the product of a Schur function and a single row Schur function in terms of Schur functions. We extend the classical Pieri rule by expressing the product of a skew Schur function and a single row Schur function in terms of skew Schur functions. Like the classical rule, our rule involves simple additions of boxes to the original skew shape. We also give a conjecture (recently proven by Sottile and Lauve) for a skew Littlewood-Richardson rule. (Received September 22, 2009)

1056-05-1582 **Stefan Felsner**, **Chingman Li** and **William T. Trotter*** (trotter@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332. *Adjacency Posets of Planar Graphs.*

In this paper, we show that the dimension of the adjacency poset of a planar graph is at most 8. From below, we show that there is a planar graph whose adjacency poset has dimension 5. We then show that the dimension of the adjacency poset of an outerplanar graph is at most 5. From below, we show that there is an outerplanar graph whose adjacency poset has dimension 4. We also show that the dimension of the adjacency poset of a planar bipartite graph is at most 4. This result is best possible. More generally, the dimension of the adjacency poset of a graph is bounded as a function of its genus. (Received September 22, 2009)

1056-05-1585 **Richard Ehrenborg*** (jrge@ms.uky.edu), Department of Mathematics, Lexington, KY 40506-0027, and **JiYoon Jung** (jjung@ms.uky.edu), Department of Mathematics, Lexington, KY 40506-0027. *Extension of the d-divisible partition lattice.*

For a composition $\vec{c}$ of $n$ we introduce a subposet $\Pi_{\vec{c}}$ of the partition lattice $\Pi_{n+1}$. Our work on this extension is motivated by enumerative results of Richard Stanley and topological results of Michelle Wachs on the $d$-divisible partition lattice, which corresponds to the composition $(d, \ldots, d, d-1)$. We show the Möbius function of $\Pi_{\vec{c}}$ is given by $\beta(\vec{c})$, that is, the number of permutations of $\mathfrak{S}_n$ with descent composition $\vec{c}$. Moreover, the poset $\Pi_{\vec{c}}$ has an $EL$-labeling, hence its order complex is a wedge of $\beta(\vec{c})$ spheres. We describe the cycles in the top homology and show they are homeomorphic to the barycentric subdivision of a Cartesian product of root polytopes. We also describe the representation of the symmetric group $\mathfrak{S}_n$ acting on the top homology. (Received September 22, 2009)

1056-05-1586 **Jim Haglund*** (jhaglund@math.upenn.edu), 209 S. 33rd. St., Math. Dept., Univ. of Penn., Philadelphia, PA 19104-6395. *Experimental Investigations into the Zeros of Rook Polynomials and Analytic Functions.* Preliminary report.

We discuss a multivariate refinement (due to the speaker and M. Visontai) of a conjecture from 1996 of Ono, Wagner, and the speaker involving the zeros of a certain pernament related to the theory of matching and rook polynomials. Connections with results involving polynomials with only real zeros are discussed. We also introduce some conjectures involving the zeros of approximates to the Riemann Xi-function and incomplete gamma functions, based on Maple calculations. (Received September 22, 2009)

1056-05-1607 **John Shareshian*** (shareshi@math.wustl.edu) and **Michelle L Wachs** (wachs@math.miami.edu). *Eulerian quasisymmetric functions.*

Given a permutation $w \in S_n$ written in one line notation, place a bar over each excedance in $w$ to obtain $\bar{w}$. Order the alphabet of barred and unbarred symbols by

$$\bar{1} < \ldots < \bar{n} < 1 < \ldots < n.$$

Define $DEX(w)$ to be the descent set of $\bar{w}$ with respect to the given ordering, and let $F_w$ be the fundamental quasisymmetric function associated to $DEX(w)$. It turns out that for certain subsets $X$ of $S_n$, the sum of $F_w$

over $X$ is a symmetric function. Such sums, which we call Eulerian quasisymmetric functions, have turned out to be useful in the examination of permutation statistics. I will discuss recent work in our ongoing study of Eulerian quasisymmetric functions. (Received September 22, 2009)

1056-05-1620 **Jim Pitman***, Dept. Statistics, 367 Evans Hall #3860, University of California, Berkeley, CA 94720-3860. *Permutations associated with random interval partitions.* Preliminary report.

This talk will review some recent progress and present some open problems about random permutations associated with models for randomly partitioning an interval into a countably infinite collection of subintervals. (Received September 22, 2009)

1056-05-1636 **Karin R. Saoub*** (saoub@roanoke.edu), Roanoke College, 221 College Lane, Salem, VA 24153, and **H. A. Kierstead**, Arizona State University, Tempe, AZ 85287. *First-Fit coloring of $p$-tolerance graphs.*

There has been extensive study on the First-Fit coloring of interval graphs. Kierstead proved in 1988 that $\chi_{FF}(G) \leq 40\omega(G)$ for any interval graph, which was later improved to $26\omega(G)$ by Kierstead and Qin [1992]. Using a brilliant new technique, Pemmaraju, Raman, and Varadarajan lowered the upper bound to $10\omega(G)$ [2004]. By a slight modification Narayanaswamy and Babu, and independently Brightwell, Kierstead, and Trotter, were able to reduce the upper bound to $8\omega(G)$.

In trying to extend these results to tolerance graphs, we introduce a new class of bounded tolerance graphs, $p$-tolerance graphs, in which the ratio between the length of an interval and the tolerance is at most $p$. We show that if $G$ is a $p$-tolerance graph with $\omega(G) = \omega$ then $\chi_{FF}(G) = \Theta\left(\lceil\frac{1}{1-p}\rceil\omega\right)$. In particular, by modifying the technique from Pemmaraju et. al, we show that $\chi_{FF}(G) \leq 8\lceil\frac{1}{1-p}\rceil\omega(G)$. We will also note that this cannot be extended to all bounded tolerance graphs as Kierstead constructed bounded tolerance graphs with arbitrarily large First-Fit chromatic number and clique size 2 [1991]. (Received September 22, 2009)

1056-05-1709 **Persi Diaconis**, Department of Statistics, Sequoia Hall, 390 Serra Mall, Stanford, CA 94305, and **Jason Fulman*** (fulman@usc.edu), USC Department of Math, KAP 108 - MC 2532, 3620 South Vermont Avenue, Los Angeles, CA 90089. *Carries and shuffling.*

We survey some connections between carries of arithmetic and random permutations obtained from card shuffling on the symmetric and hyperoctahedral groups. This talk is based on joint work with Persi Diaconis, and will be accessible to a general audience. (Received September 22, 2009)

1056-05-1715 **Glenn G Chappell** (chappellg@member.ams.org) and **Michael J Pelsmajer*** (pelsmajer@iit.edu), 10 W. 32nd St., E1 208, Chicago, IL 60616. *Maximum Induced Forests in Graphs of Bounded Treewidth.*

Let $f_{k,d,n}$ be the maximum $i$ such that every $n$-vertex graph of treewidth $k$ contains an $i$-vertex induced forest of maximum degree at most $d$. We prove that for all $k, d \geq 2$ and for all $n \geq 1$, $f_{k,d,n} \geq \lceil(2dn+2)/(kd+d+1)\rceil$ unless $G \in \{K_{2,3}, K_{1,1,3}\}$ and $k = d = 2$. We give examples that show that the bound is sharp to within 1.

We conjecture that $f_{k,1,n} \geq \lceil 2n/(k+2)\rceil$, which would be sharp to within 1, and we prove it for $k = 2, 3$. For $k \geq 4$, we show that $f_{k,1,n} \geq (2n+2)/(2k+3)$. We also determine $f_{k,d,n}$ when $d = 0$ or $k = 0, 1$. Finally, we consider an analogue of $f_{k,d,n}$ for graphs on a given surface, rather than graphs of a given treewidth. (Received September 22, 2009)

1056-05-1731 **Ralucca Gera**, Naval Postgraduate School, **Grady Bullington** (eroh@uwosh.edu), University of Wisconsin Oshkosh, **Linda Eroh*** (eroh@uwosh.edu), University of Wisconsin Oshkosh, 800 Algoma Blvd., Oshkosh, WI 54963, and **Steven J Winters**, University of Wisconsin Oshkosh. *On $k$-circuit distance in graphs.*

A delivery person must leave a central location, deliver packages at a number of addresses, and return. Naturally, he/she wishes to find the most efficient route. This motivated the definition of $(k-1)$-stop-return distance by Gadzinski, Sanders, and Xiong, now called $k$-circuit distance. Given a set of $k$ distinct vertices $\mathcal{S} = \{x_1, x_2, \ldots, x_k\}$ in a simple graph $G$, the $k$-circuit-distance of set $\mathcal{S}$ is defined to be

$$d_k(\mathcal{S}) = \min_{\theta\in\mathcal{P}(\mathcal{S})} \Big(d(\theta(x_1),\theta(x_2)) + d(\theta(x_2),\theta(x_3)) + \ldots + d(\theta(x_k),\theta(x_1))\Big),$$

where $\mathcal{P}(\mathcal{S})$ is the set of all permutations from $\mathcal{S}$ onto $\mathcal{S}$. Thus, $d_k(x_1,\ldots,x_k)$ is the length of the shortest circuit through the vertices $\{x_1,\ldots,x_k\}$.

The 2-circuit distance is twice the standard distance between two vertices. We present results about the $k$-circuit radius, $k$-circuit diameter, $k$-circuit center and $k$-circuit periphery, with particular attention to $k = 3$. We also note some relationships between $k$-circuit distance and Steiner distance. (Received September 22, 2009)

1056-05-1749 **Jeffrey Mudrock*** (mudrock2@illinois.edu), **Lucas Allen**, **Ryan Bunge**, **Saad El-Zanati**, **Daniel Gannon**, **Kyle Knee** and **Jessica Smith**. *On $\lambda$-fold Rosa-type Labelings.*

Let $V(K_n) = \mathbb{Z}_n$ and define the *length* of an edge $\{i,j\} \in E(K_n)$ to equal $\min\{|i-j|, 2n+1-|i-j|\}$. A *Rosa-type labeling* of a graph $G$ with $n$ edges is an embedding of $G$ in $K_{2n+1}$ (with $V(K_{2n+1}) = \mathbb{Z}_{2n+1}$) that has exactly one edge of each length $i$ for $1 \le i \le n$. Rosa-type labelings with additional restrictions lead to cyclic $G$-decompositions of either $K_{2n+1}$ or of $K_{2nx+1}$ for all positive integers $x$. Understandably, labelings that lead cyclic $G$-decompositions of $K_{2nx+1}$ are deemed more useful. We introduce the concept of a $\lambda$-fold Rosa-type labeling of a graph $G$ of size $n$ and show that some of these labelings lead to cyclic $G$-decompositions of the $\lambda$-fold complete multigraph ${}^{\lambda}K_{\frac{2nx}{\lambda}+1}$ for all positive integers $x$. These results were obtained at an REU Site for Pre-service and In-service Secondary Mathematics Teachers at Illinois State University. (Received September 22, 2009)

1056-05-1774 **Ermelinda Delavina** and **Craig Eric Larson*** (clarson@vcu.edu), 4106 Grace E. Harris Hall, 1015 Floyd Avenue, Richmond, VA 23284-2014. *A Parallel Algorithm for finding Maximum Critical Independent Sets in Graphs.*

An independent set of vertices $I_c$ in a graph is a critical independent set if $|I_v| - |N(I_c)| \ge |J| - |N(J)|$, for any independent set $J$. A maximum critical independent set (MCIS) is a critical independent set on maximum cardinality. Maximum critical independent sets have been shown to be of both practical and theoretical interest. The published algorithm has a running time of $O(\sqrt{n}en)$. Determining whether a vertex $v$ is in *some* MCIS can be determined without finding an MCIS containing $v$. Thus, the vertices can be tested in parallel. This is the main step in a new algorithm for finding a MCIS with a running time of $O(\sqrt{n}e)$. The algorithm also yields the set $C$ of all vertices in an MCIS, and we discuss properties of this set. (Received September 22, 2009)

1056-05-1775 **Desiree Masters*** (masters.tdm@gmail.com), **Ryan Bunge**, **Saad El-Zanati**, **Theresa Kamykowski** and **Isai Almeida-Arrieta**. *On Cyclic Cycle Plus a Chord Designs.*

Let $G$ be the graph consisting of a cycle of length $n-1$ plus a chord $e$. We investigate necessary and sufficient conditions for the existence of cyclic $G$-decompositions of the 2-fold complete multigraph ${}^{2}K_{nx+1}$ for every positive integer $x$. These results were obtained at an REU Site for Pre-service and In-service Secondary Mathematics Teachers at Illinois State University. (Received September 22, 2009)

1056-05-1785 **Alexander Postnikov*** (apost@math.mit.edu), 77 Mass Ave, Cambridge, MA 02139, and **Federico Ardila**. *Power Ideals.*

A power ideal is an ideal in the polynomial ring generated by powers of some linear forms. Examples of such ideals appear in many different areas of mathematics, say, in Schubert calculus and in box spline theory. We study several classes of ideals of this form and calculate their Hilbert series. We discuss their combinatorial properties, connections with hyperplane arrangements, Tutte polynomial, and parking functions. (Received September 22, 2009)

1056-05-1787 **Fan Chung** (fan@ucsd.edu), **Anders Claesson** (anders.claesson@gmail.com), **Mark Dukes** (dukes@hi.is) and **Ron Graham*** (graham@ucsd.edu), 1555 Coast Walk, La Jolla, CA 92037. *Descents and drops of permutations.* Preliminary report.

In this talk we will describe some recent results on the joint distribution of the descent and maximum drop statistics of a permutation. Several new identities for Eulerian numbers also follow from this analysis. (Received September 22, 2009)

1056-05-1796 **Nathan H Reff*** (reff@math.binghamton.edu), 3125 Burris Rd. Apt. 9, Vestal, NY 13850. *Spectral Properties of Abelian Gain Graphs.* Preliminary report.

A gain graph is a graph whose edges are labelled invertibly by elements of a group $\mathfrak{G}$. I extend some fundamental concepts from spectral graph theory to gain graphs for which $\mathfrak{G}$ is abelian. (Received September 22, 2009)

1056-05-1806 **M Amin Bahmanian*** (amin.b@auburn.edu), Auburn University, Department of Mathematics, Roosevelt Drive, Parker Hall 221, Auburn, AL 36849-0001, and **C A Rodger** (rodgec1@auburn.edu), Auburn University, Department of Mathematics, Roosevelt Drive, Parker Hall, Auburn, AL 36849. *Multigraph Detachments, Hamiltonian Decompositions and Graph Embeddings.*

In this talk we present some recent progresses we have made on detachments of multigraphs using edge coloring techniques. We then show that these imply necessary and sufficient conditions for $K(a_1, \ldots, a_n, \lambda_1, \lambda_2)$ to be decomposable into Hamilton cycles or to be decomposable into Hamilton cycles and a single 1-factor, where

$K(a_1, \ldots, a_p; \lambda_1, \lambda_2)$ is a graph with $p$ parts, the $i^{th}$ part having size $a_i$, in which the multiplicity of each pair of vertices in the same part (in different parts) is $\lambda_1$ ($\lambda_2$, respectively). An attempt to generalize this decomposition result will be given thereafter with a relevant conjecture. Finally, if time permits, we use our detachment technique to prove some graph embedding problems. (Received September 22, 2009)

1056-05-1813 **Ji Young Choi*** (jychoi@ship.edu), 1871 Old Main, Dept of Math, Shippensburg, PA 17257. *Multi-restrained Stirling numbers.* Preliminary report.

Given a positive integer $m$ and nonnegative integers $n$ and $k$, the $(n, k)$-th $m$-restrained Stirling numbers of the first kind is the number of permutations of an $n$-set with $k$ disjoint cycles of length $\leq m$. By inversing the matrix consisting of the $(n, k)$-th $m$-restrained Stirling numbers of the first kind as the $(n, k)$-th entry, the $(n, k)$-th $m$-restrained Stirling numbers of the second kind are defined. In this talk, the explict formulae, reccurence relations, and generating functions of the multi-restrained Stirling numbers of the first and the second kids will be presented, and a new generating function for the Stirling numbers of the first kind will be introduced. (Received September 22, 2009)

1056-05-1831 **Tom Boothby**, **Jeffrey Burkert**, **Morgan Eichwald** and **Dana C. Ernst*** (dcernst@plymouth.edu), Mathematics Department, Plymouth State University, MSC 29, 17 High Street, Plymouth, NH 03264, and **Richard M. Green** and **Matthew Macauley**. *On the cyclically fully commutative elements of Coxeter groups.*

Let $W$ be a Coxeter group. We say that $w \in W$ is cyclically fully commutative (CFC) if every cyclic shift of every reduced expression for $w$ is fully commutative (in the sense of Stembridge). This definition is motivated by the conjugacy problem, because a cyclic shift of $w \in W$ is simply conjugation by the shifted generator. An element $w$ in an infinite irreducible Coxeter group is said to be logarithmic if $l(w^k) = kl(w)$ for all $k \geq 1$. Speyer recently proved that Coxeter elements are logarithmic. In this talk, we will discuss one of our recent results that shows that for a large class of Coxeter groups, including all affine Weyl groups, CFC elements are logarithmic. This result gives credence to the idea that CFC elements are a natural generalization of Coxeter elements, and we outline the significance of this result to current and future work on the conjugacy problem for Coxeter groups. (Received September 22, 2009)

1056-05-1856 **Federico Ardila*** (federico@math.sfsu.edu), Department of Mathematics, San Francisco State University, 1600 Holloway Ave., San Francisco, CA 94132. *Double Hurwitz numbers as splines.* Preliminary report.

The Double Hurwitz number $H_d^g(\mu, \nu)$ counts the genus g, degree d covers of $\mathbb{P}^1$ which have ramification profiles $\mu$ and $\nu$ at 0 and $\infty$, and simple ramification elsewhere. By thinking of double Hurwitz numbers as splines, we prove several results about their rich combinatorial structure. Two important tools are Cavalieri-Johnson-Markwig's work on tropical Hurwitz numbers and De Concini-Procesi-Vergne's algebraic approach to the index of transversally elliptic operators.

The talk will be elementary, and will assume no previous knowledge of Hurwitz numbers. (Received September 22, 2009)

1056-05-1861 **Tom Boothby** and **Jeffrey Burkert*** (jeffrey.burkert@gmail.com), Harvey Mudd College, 340 E. Foothill Blvd, Claremont, CA 91711, and **Morgan Eichwald**, **Dana C. Ernst**, **Richard M. Green** and **Matthew Macauley**. *On the enumeration of the cyclically fully commutative elements in Coxeter groups.*

Let $W$ be a Coxeter group. We say that $w \in W$ is cyclically fully commutative (CFC) if every cyclic shift of every reduced expression for $w$ is fully commutative (in the sense of Stembridge). This definition is motivated by the conjugacy problem, because a cyclic shift of $w \in W$ is simply conjugation by the initial generator. In this talk, we characterize the CFC elements in the Coxeter groups containing finitely many fully commutative elements, and enumerate them via a recurrence relation. In Type $A$, the CFC elements are precisely the permutations that avoid the patterns 321 and 3412, which are counted by the odd Fibbonacci numbers. (Received September 22, 2009)

1056-05-1863 **Tong Zhu*** (tongzhu@sas.upenn.edu), 209 South 33rd Street, Department of Mathematics, Philadelphia, PA 19104. *A probability method to prove combinatorial identities.*

A novel and extremely simple probability method is provided to prove combinatorial identities. It has only one step of proof after proper probability setup. This method applies summations of random variables and the density function of the summation. The inherent relations between the probability structure and the combinatorial identities are also discussed, as well as some future development and open problems on this method. I proved three classes of combinatorial identities. The first class is a group of combinatorial identities involving symmetric functions. The second class contains convolution of two sequences. And the third result gives an identity involving multinomial convolution. A special case provides a new way to prove a basic formula concerning the Stirling numbers of the second kind. (Received September 23, 2009)

1056-05-1881 **Adriano Garsia*** (agarsia@ucsd.edu). *Invariants, Kronecker products and combinatorics of some remakable diophantine systems*

I will discuss invariants, Kronecker products and combinatorics of some remakable diophantine systems. (Received September 22, 2009)

1056-05-1886 **Einar Steingrimsson*** (einar@alum.mit.edu). *A hierarchy of generalized pattern avoidance and $\beta(0,1)$-trees.*

A $\beta(0,1)$-tree is an instance of so called description trees introduced by Cori, Jacquard, and Schaeffer in 1997 to give a general framework for the recursive decompositions of several families of planar maps studies by Tutte, and Brown and Tutte.

We consider a hierarchy (by set inclusion) of sets of permutations avoiding generalized patterns based on the permutations 2413 and 3142. Objects related to this hierarchy are *2-stack sortable permutations*, *Baxter permutations*, *Schröder paths*, *plane permutations*, *rooted plane trees with marked leaves*, *$\beta(1,0)$-trees*, and *forests of $\beta(0,1)$-trees*. We show that several of the patten avoiding classes, and thus several of the objects mentioned above, can be embedded into $\beta(0,1)$-trees. As a particular consequence, we have an induced embedding of one family of planar maps into another one.

The hierarchy we are considering can all be modeled with sets of pattern avoiding permutations. We seek a different structure, with a more transparent recursive construction, into which we can embed the entire hierarchy. It is not yet clear whether $\beta(0,1)$-trees, or some variation on these, can serve as that structure.

This is joint work with A. Claesson and S. Kitaev. (Received September 22, 2009)

1056-05-1888 **Bruce Sagan**, **John Shareshian** and **Michelle L Wachs*** (wachs@math.miami.edu), Department of Mathematics, University of Miami, Coral Gables, FL 33124. *Eulerian quasisymmetric functions and cyclic sieving.*

It is shown that a refined version of a q-analogue of the Eulerian numbers together with the action, by conjugation, of the subgroup of the symmetric group $S_n$ generated by the $n$-cycle $(1,2,\ldots,n)$ on the set of permutations of fixed cycle type and fixed number of excedances provides an instance of the cyclic sieving phenonmenon of Reiner, Stanton and White. The main tool is a class of symmetric functions recently introduced in work of two of the authors. (Received September 22, 2009)

1056-05-1921 **Adegoke S Osifodunrin*** (asa_osifodunrin@yahoo.com), Department of Mathematical Sciences, Georgia Southern University, P.O. Box 8093, Statesboro, GA 30460, and **Ken. W Smith** (kenwsmith@shsu.edu), Sam Houston State University, Dept. of Mathematics and Statistics, P. O. Box 2206, Huntsville, TX 77341-2206. *On the Non-existence of $(160,54,18)$ Difference Sets.*

Much has been written in recent years, investigating the existence of the (160, 54, 18) parameter set. This parameter set belongs to the family of difference sets with parameters $(p^s\frac{(r^{2m}-1)}{r-1}, p^{s-1}r^{2m-1}, p^{s-2}(r-1)r^{2m-2})$, where $p$ is a prime, $r=\frac{p^s-1}{p-1}$, $s\geq 2$ and $m\geq 1$, when $p=s=m=2$. The search for difference sets with these parameters was motivated by the discovery of the first design with these parameters in 1993 by Spence et al.. Lander (1983), Kipilovich (1989) and Ma et al.(1999) ruled out the existence of difference sets in all (seven) abelian groups of order 160, while Pollatsek et al.(2003) showed that any group of order 160 with homomorphic image $D_{10}\times C_2$ or $(C_2)^5$ or abelian homomorphic image of exponent 2, 4, 5 or 10 with order greater than 20 does not admit (160, 54, 18) difference sets. In this paper, we explore groups of order 160, $G$, by considering the images of hypothetical difference sets in some factor groups $G/N$, where $N$ is a suitable normal subgroup. Thus, if (160, 54, 18) difference sets exist, it must be in the group $G=((C_2)^4\rtimes C_5)\rtimes C_2$, with GAP location number [160, 234]. (Received September 22, 2009)

1056-05-1939 **Anders Claesson***, The Mathematics Institute, School of Computer Science, Reykjavik University, 103 Reykjavik, Iceland, and **Svante Linusson**. *$n!$ matchings, $n!$ posets.*

Bousquet-Mélou, Claesson, Dukes and Kitaev [arXiv:08060666] gave bijections between four classes of combinatorial objects, thus proving that they are equinumerous: certain matchings due to Stoimenow; unlabeled $(2+2)$-free posets; permutations avoiding a specific pattern; and so called ascent sequences. Inspired by their work we define a natural superset of Stoimenow's matchings whose cardinality is shown to be $n!$. Moreover, we define a set of labeled $(2+2)$-free posets, also of cardinality $n!$. Finally, we state a conjecture concerning the distribution of the pattern considered by Bousquet-Mélou et al. (Received September 22, 2009)

1056-05-1950 **Hillary Einziger*** (hillaryre@gmail.com), Department of Mathematics, GWU, Monroe Hall, Room 240, 2115 G St. NW, Washington, DC 20052. *A map from chains in the noncrossing partition lattice to polygon dissections.*

We introduce a surjective map from the set of maximal chains of the lattice of noncrossing partitions of $[n+1]$ to the set of even polygon dissections of the $(2n+2)$-gon. There is a clear correspondence between the product of the intervals in the chain and the sizes of the regions of the dissection. We use this map to define an explicit formula for the antipode in the incidence Hopf algebra of noncrossing partition lattices. (Received September 22, 2009)

1056-05-1951 **Eric Sundberg*** (sundberg@oxy.edu), Mathematics Department, 1600 Campus Rd, Los Angeles, CA 90041, and **Klay Kruczek** (kruczekk@wou.edu), Mathematics Department, 345 North Monmouth Ave, Monmouth, OR 97361. *A winning strategy for Maker in the Maker-Breaker version of Tic-Tac-Toe on the integer lattice with numerous winning line directions.*

We consider a Tic-Tac-Toe game played on the $d$-dimensional integer lattice. The game that we investigate is a Maker-Breaker version of Tic-Tac-Toe. In a Maker-Breaker game, the first player, Maker, only tries to occupy a winning line and the second player, Breaker, only tries to stop Maker from occupying a winning line. We consider the bounded number of directions game, in which we designate a finite set of direction-vectors $\mathcal{S} \subset \mathbb{Z}^d$ which determines the set of winning lines. We show that Maker can build winning lines of length up to $(1+o(1))d\lg k$ if $\mathcal{S}$ is the set of *all* direction-vectors with coordinates bounded by $k$. We also apply similar methods to the $n$-consecutive lattice points game on the $N^d$ board with (essentially) $\mathcal{S} = \mathbb{Z}^d$, and we show that the phase transition from a win for Maker to a win for Breaker occurs at $n = (d+o(1))\lg N$. (Received September 22, 2009)

1056-05-1961 **Benjamin J Young*** (byoung@math.mcgill.ca), Burnside Hall, Room 1005, 805 Sherbrooke Street West, Montreal, Quebec H3A 2K6, Canada. *Generating functions for box-counting problems.*

One way to compute generating functions for various types of 3D partition-like structures, including 3D Young diagrams (plane partitions) and "pyramid partitions", is to use *vertex operators.* We will describe a broader class of "box-counting" problems which subsumes these two examples, and give the generating functions for each, using the vertex operator technique. (Received September 22, 2009)

1056-05-1999 **Erik E Westlund*** (eewestlu@mtu.edu), Department of Mathematical Sciences, Michigan Technological University, 1400 Townsend Drive, Houghton, MI 49931. *The Hamiltonian decomposition problem for Cayley graphs on abelian groups.*

Alspach conjectured that every $2k$-regular connected Cayley graph on a finite abelian group $A$ with connection set $S = \{s_1, \ldots, s_k\}$ has a hamiltonian decomposition. In 2009, the conjecture was proved for 6-regular graphs of odd order. This talk discusses techniques used to generalize this result for even order graphs. (Received September 22, 2009)

1056-05-2013 **Glenn P Tesler*** (gptesler@math.ucsd.edu), Department of Mathematics, University of California, San Diego, La Jolla, CA 92093-0112. *Distribution of Segment Lengths in Genome Rearrangements.*

The study of gene orders for constructing phylogenetic trees was introduced by Dobzhansky and Sturtevant in 1938. Different genomes may have homologous genes arranged in different orders. In the early 1990s, Sankoff and colleagues modelled this as permutations on a set of numbered genes $1, 2, \ldots, n$, with biological events such as inversions modelled as operations on the permutations. Signed permutations are used to indicate relative strands of the genes, and circular permutations are used for circular genomes. We use combinatorial methods (generating functions, asymptotics, and enumeration formulas) to study the distributions of the number and lengths of conserved segments of genes between multiple genomes, including signed and unsigned genomes, and circular and linear genomes. This generalizes classical work from the 1940s–60s by Wolfowitz, Kaplansky, Riordan, Abramson, and Moser, who studied decompositions of permutations into strips of ascending or descending consecutive numbers. In our setting, their work corresponds to comparison of two unsigned genomes (known gene orders, unknown gene orientations). (Received September 22, 2009)

1056-05-2014 **Teresa Haynes**, 312 Gilbreath Hall, PO Box 70663, Johnson City, TN 37614, **Debra Knisley**, 312 Gilbreath Hall, PO Box 70663, Johnson City, TN 37614, and **Denise Koessler*** (Denise.Koessler@gmail.com), 312 Gilbreath Hall, PO Box 70663, Johnson City, TN 37614. *Bonding Tree Models of RNA Structures.* Preliminary report.

Understanding the formation of RNA structures from base pairings is an open problem in biological research. We apply graph theory to study this problem. Through a project supported by the National Science Foundation, the New York University RNA team provides an online database of trees representing possible secondary RNA structures. Considering these graphical models, we ascertain the frequency of occurrence of a tree by determining all possible ways two smaller trees could bond together to form it. In graph theory, two vertices are said to be identified if they are combined into a single vertex whose neighborhood is their neighborhood union. We use this process to model the bonding of base pairs of RNA tree structures to form a single tree. This novel approach could give insight into the likelihood of the tree existing in nature as an RNA structure. (Received September 22, 2009)

1056-05-2048 **Radhika Ramamurthi***, 333 S. Twin Oaks Valley Road, Department of Mathematics, San Marcos, CA 92096, and **Andre Kundgen** and **Michael Pelsmajer**. *Finding minors in graphs with a given path structure.*

A *scheme* of a graph $H$ in a graph $G$ with $V(H) \subseteq V(G)$ is a collection of $|E(H)|$ paths, consisting of one $u, v$-path in $G$ for each edge $uv$ in $H$. An $H$-subdivision corresponds to a scheme in which the paths are internally vertex disjoint, whereas an $H$-immersion corresponds to a scheme in which the paths are edge-disjoint.

The study of $H$-schemes that force $G$ to have an $H$-minor naturally leads to $H$-immersions with the additional property that all paths in the scheme that contain the same vertex must have a common endpoint. If $H$ has the property that every graph $G$ with such an $H$-immersion contains a rooted $H$-minor, then we call $H$ *contractible.*

We show that $K_4, K_{2,3}$, trees and cycles are contractible, but that complete graphs on more than 6 vertices as well as many subdivisions of $K_{2,3}$ are not contractible. (Received September 23, 2009)

1056-05-2083 **Jonathan Darren Hulgan*** (jhulgan@memphis.edu), Department of Mathematical Sciences, The University of Memphis, Memphis, TN 38152, and **Jeno Lehel**, **Kenta Ozeki** and **Kiyoshi Yoshimoto**. *Vertex coloring of graphs by total 2-weightings.*

An assignment of real weights to the edges and the vertices of a graph is a vertex-coloring total weighting if the total weight sums at the vertices are distinct for any two adjacent vertices. Of interest in this paper is the existence of vertex-coloring total weightings with weight set of cardinality two, a problem motivated by the conjecture that every graph has a such a weighting using the weights 1 and 2. Here we prove the existence of such weightings for certain families of graphs using any two distinct non-negative real weights. (Received September 23, 2009)

1056-05-2141 **Qiang Wang*** (xqwang@math.ucdavis.edu), Mathematics Department, University of California, One Shield Ave, Davis, CA 95616, and **Steven Pon** (spon@math.ucdavis.edu), Mathematics Department, University of California, One Shield Ave, Davis, CA 95616. *Promotion acting on Standard Young Tableaux of staircase shape.* Preliminary report.

On the set of standard Young tableaux $SSTY(\lambda)$, there is a bijection called promotion first defined by Schützenberger. Rrendon Rhoades recently showed that for $\lambda$ being rectangular shape, promotion acting on $SSYT(\lambda)$ exhibits the *cyclic sieving phenomenon* (CSP). As a result, the complete cycle structure of the action is recovered. In this paper, we report a partial solution to the problem where $\lambda$ is the staircase shape, and conjecture the realization of CSP polynomial as a product of cyclotomic polynomials. (Received September 23, 2009)

1056-05-2152 **Alexei Borodin***, Department of Mathematics, California Institute of Technology, Pasadena, CA 91125. *From random permutations to random matrices — an alternative for RSK*

The Robinson-Schensted-Knuth correspondence played a central role in evaluating the asymptotics of the longest increasing subsequence of random permutations (Baik-Deift-Johansson theorem) and in similar problems. The goal of the talk is to describe a different, somewhat simpler combinatorial procedure that relates random (generalized) permutations to random matrix like distributions. (Received September 28, 2009)

# 06 ► Order, lattices, ordered algebraic structures

1056-06-89 **Fusun Akman*** (akmanf@ilstu.edu), Illinois State University, Department of Mathematics, Campus Box 4520, Normal, IL 61790-4520, and **Papa Amar Sissokho**. *The lattice of finite vector space partitions and its Möbius function.*

Let $V = V(n, q)$ denote the vector space of dimension $n$ over $GF(q)$. A vector space partition of $V$ is a collection $\Pi$ of subspaces of $V$ such that every nonzero vector in $V$ is contained in exactly one subspace belonging to $\Pi$. We show that the set of all vector space partitions of $V$ form a poset under refinement, with unique minimum and maximum elements, and introduce a lattice structure on it. Furthermore, we compute the Möbius function of this poset for small $n$ and conjecture that its value approaches that of the Mobius function of a set partition as $q \to 1$. (Received July 24, 2009)

1056-06-594 **Joris van der Hoeven**, **Salma Kuhlmann** and **Mickaël Matusinski*** (mickael.matusin@gmail.com), University of Konstanz, Fachbereich Mathematik und Statistik, 78457 Konstanz, Germany. *Surreal numbers as transseries.*

Several similar constructions - namely Logarithmic-Exponential (Aschenbrenner - van den Dries), Exponential-Logarithmic (Kuhlmann) and Transseries (Ecalle - van der Hoeven) fields - have been made, all starting with some formal power series fields. The aim is to produce non archimedean ordered fields closed under an exponential map (i.e. a morphism from the additive group to the multiplicative one of positive elements). Moreover such exponential fields can be provided with "natural" derivations (Kuhlmann Matusinski / van der Hoeven - Schmeling). Our aim is to show that the field NO of surreal numbers is such a transseries fields, and thus turns out to be a model of differential exponential fields. (Received September 14, 2009)

1056-06-612 **Joris van der Hoeven*** (vdhoeven@lix.polytechnique.fr), LIX, Ecole Polytechnique, 91128 Palaiseau, France. *Transseries, a survey.*

A transseries is a formal object built up from the reals and an infinitely large indeterminate x using exponentiation, logarithm and infinite summation. Transseries naturally come up in various areas of mathematics: analysis, model theory, computer algebra. In my talk, I will give a survey of the subject and its connection to surreal numbers. (Received September 14, 2009)

1056-06-739 **John Harding** and **Qin Yang*** (qyang@nmsu.edu), PO BOX 30001, Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88003-8001. *Regular completions of lattices.*

We know that the varieties of lattices admitting MacNeille completions are the variety of one-element lattices and the variety of all lattices. A variety of lattice admits a regular completion if every lattice in the variety can be embedded into a complete lattice in the variety by an embedding that is regular (preserves existing joins and meets). It remains an open problem whether the only varieties of lattices admitting a regular completion are the trival variety and the variety of all lattices. We'll show that there are only two varieties of lattices admitting a meet dense regular completion: the trival variety and the variety of all lattices. (Received September 16, 2009)

1056-06-768 **Paul Steven Brodhead*** (pbrodhead@vsu.edu), Department of Mathematics & Computer Science, P.O. Box 9068, Carter G. Woodson Ave, Hunter McDaniel Building, Room 303Sd, Petersburg, VA 23806, and **Bjørn Kjos-Hanssen** (bjoern@math.hawaii.edu), Department of Mathematics, 2565 McCarthy Mall, Keller 401A, Honolulu, HI 96822. *The Strength of the Grätzer-Schmidt Theorem.*

The Grätzer-Schmidt theorem of lattice theory states that each algebraic lattice is isomorphic to the congruence lattice of an algebra. A lattice is algebraic if it is complete and generated by its compact elements. We show that the set of indices of computable lattices that are complete is $\Pi^1_1$-complete; the set of indices of computable lattices that are algebraic is $\Pi^1_1$-complete; and that there is a computable lattice $L$ such that the set of compact elements of $L$ is $\Pi^1_1$-complete. As a corollary, there is a computable algebraic lattice that is not computably isomorphic to any computable congruence lattice. (Received September 17, 2009)

1056-06-1000 **Ryan K Therkelsen*** (rtherke@ncsu.edu), Department of Mathematics, North Carolina State University, Box 8205, Raleigh, NC 27695-8205. *Results on the Order Between Orbits in the Conjugacy Decomposition of a Canonical Monoid.* Preliminary report.

The conjugacy poset $\mathcal{C}$ of a reductive monoid $M$ plays an important role in describing the irreducible components of the nilpotent variety of $M$. Specifically, the maximal elements of the subposet of nilpotent elements of $\mathcal{C}$ correspond to these irreducible components. The order in $\mathcal{C}$ is quite complicated and, in general, is difficult to use. In this talk, we provide a nicer description of this order for the case that $M$ is a canonical monoid (such monoids are crucial in the representation theory of finite reductive monoids). Given the usual decomposition into classes indexed by idempotents of $M$, we briefly outline known results on this order within such classes before presenting a new description of the order between the classes. (Received September 19, 2009)

1056-06-1283 **Benjamin Wells*** (wells@usfca.edu), Department of Mathematics, University of San Francisco, 2130 Fulton Street, San Francisco, CA 94117. *A gap theorem for the poset of sequential degrees.* Preliminary report.

Let $m = \{0, 1, ..., m-1\}$ be the finite alphabet for a finite-state no-delay machine (or Moore transducer) $M$ with states $Q_M$, initial state $I_M$, state-transition function $(q, k) \to qk$, and output function $\mathcal{O}_M : Q_M \to m$. For $\alpha, \beta \in {}^\omega m$, $\alpha M = \beta$ when inductively defined states and outputs satisfy $q_0 = I_M\alpha_0, q_{i+1} = q_i\alpha_{i+1}$, and $q_i\mathcal{O}_M = \beta_i$ for all $i \in \omega$. We write $\alpha \Rightarrow \beta$ and say $\beta$ is *sequentially reducible to* $\alpha$ iff there is such an $M$. Then $\Rightarrow$ is a preorder on ${}^\omega m$, and $D = \langle {}^\omega m/\Leftrightarrow, \Leftarrow/\Leftrightarrow\rangle$ is the corresponding poset of *sequential degrees.* Let $B_{\Omega(m)}$ be the Boolean algebra with number of generators equal to the count of nondistinct prime divisors of $m$.

**Gap Theorem.** *Let $\psi$ be an incompressible sequence. Then the shift interval of $\psi$*

$$\{\delta \in D : \psi \Leftarrow \delta \Leftarrow \psi^\sharp = \psi|^{\omega \sim \{0\}}m\}$$

*is a Boolean subalgebra order-isomorphic to $B_{\Omega(m)}$, and the order closure in $D$ of the shift chain of $\psi$ is order-isomorphic to the chain sum $B_{\Omega(m)} \oplus \mathbb{Z}$.* (Received September 21, 2009)

1056-06-1940 **Salma Kuhlmann*** (salma.kuhlmann@uni-konstanz.de), Fachbereich Mathematik und Statistik, Universitaetsstrasse 10, 78462 Konstanz, Germany, and **Saharon Shelah**. *The exponential logarithmic power series fields.*

In this talk, I will review the construction of exponential logarithmic power series fields as presented in my monograph (Fields Institute Monograph Series, Vol 12, AMS Publications, 2000). This should provide a background and framework for attacking the following problem: does Conway's field of surreal numbers carry a natural structure of exponential-logarithmic power series field? This question is currently considered in collaboration with Matusinski and van der Hoeven. (Received September 22, 2009)

1056-06-2154 **Scott Kominers***, Harvard University, Department of Mathematics, Cambridge, MA. *Configurations of extremal type II lattice and codes.*

Type II lattices and codes have been studied extensively because of their important applications to the theory of sphere packing. Using *weighted theta series*, generating functions that encode the norms and distributions of lattice vectors, Ozeki showed a series of configuration results for extremal Type II lattices of ranks 32, 40, and 48. We extend these configuration results, showing that if $L$ is an extremal Type II lattice of rank 56, 72, or 96 then $L$ is generated by its minimal-norm vectors, and if $L$ is such a lattice of rank $40r$ $(r = 1, 2, 3)$ then $L$ is generated by its vectors of lengths $4r$ and $4r + 2$. Using *harmonic weight enumerators*, discrete analogs of weighted theta functions, we obtain configuration results for extremal Type II codes of lengths 32, 48, 56, 72, and 96 analogous to the results for lattices of those ranks. (Received September 29, 2009)

# 08 ► General algebraic systems

1056-08-26 **B Sriram*** (sriramb@iitk.ac.in), Hall 2, IIT K, Kalyanpur, Kanpur, 208016. *Comparison of Homogenous cyclic expressions.*

A method to compare generalised homogeneous cyclic expressions of the form

$$\sum_{cyclic}(\prod_{i=1}^{n}(a_i^{p_i}))^* \sum_{cyclic}(\prod_{i=1}^{n}(a_i^{q_i}))$$

where $\sum p_i = \sum q_i = m$ where $m, p_i, q_i \in I^+$ $a_i \in R^+$ or $R^-$ is proposed. A principle diagonal arrangement (PDA) is defined as $a_1 \geq a_2 \geq a_3 \ldots \geq a_n$. The index of global permutation(IGP) is defined as the value of a cyclic permutation such that the arrangement $a_i \geq a_{i+1} \geq a_{i+2} \ldots \leq a_1 \geq a_2 \ldots \geq a_{i-1}$ has the IGP value $= (i-1)$. The expression $\sum_{cyclic}(\prod_{i=1}^{n}(a_i^{p_i}))$ is and can always be expressed as the product of $m$ diagonal matrices whose trace of the product matrix gives the expression. Each matrix entry is of the form that is globally cyclic conforming to a cyclic interchange of the PDA having an unique order. The method states that as the sum of the IGP over all the values for the individual matrices constituting the expression (on tracing the product matrix) is lesser than another such value for a different homogeneous cyclic expression, the expression is higher in value. Moreover if the sum is the same, then no comparison can be made. This result is proved with a natural conclusion as the method. (Received June 06, 2009)

1056-08-213 **Kate S Owens*** (kate.s.owens@gmail.com). *Shift Automorphism Varieties Are Not Residually Finite.*

An algebra is a nonempty set equipped with some finitary operations. The equational theory of an algebra is the set of all equations true in that algebra. If we can deduce all of an algebra's true equations from a finite set of equations, we say that the algebra's equational theory is finitely axiomatizable. In this talk we examine a property shared by some finite algebras whose equational theories are not finitely axiomatizable. (Received August 15, 2009)

1056-08-1553 **Debra A. Warne*** (warneda@jmu.edu), Department of Mathematics and Statistics, Roop Hall, MSC 1911, Harrisonburg, VA 22807, and **Paul G. Warne** (warnepg@jmu.edu), Department of Mathematics and Statistics, Roop Hall, MSC 1911, Harrisonburg, VA 22807. *Simply Un-Real: Grassmann hypercomplex numbers, geometric algebra, and the (past and) future of "vector" calculus.* Preliminary report.

In this talk, we place the development of vector algebra and vector calculus within its historical context, with a view toward the ongoing (re-)emergence of geometric algebra and geometric calculus, a system that could become the standard mathematics of the future for multiple dimensions. While the algebra of geometric algebra (a Clifford algebra) is well-studied, the same cannot be said for its ease of application or its geometry. We highlight a simple way to understand the algebra (and geometry) of geometric algebra (without knowing *any* high-powered mathematics). Our Grassmann hypercomplex number system defines a product for multi-dimensional numbers, and is seen to be a simple extension of well-known number systems (the reals, complex numbers, and quaternions, e.g.) that includes and surpasses our current vector algebra system–*simply unreal* ! (Received September 22, 2009)

# 11 ► Number theory

1056-11-10 **Hung-ping Tsao*** (hptsao@hotmail.com), 1151 Highland Drive, Novato, CA 94949. *Triangular arrays induced from trigonometric functions.*

Using cos2nA=2cosnAcosnA-1 and cos(2n-1)A=2cosnAcos(n-1)A-cosA, we can obtain the polynomial expressions in cosA for cosmA. Let c(m,k) denote the triangular array formed by the coefficients in question. Then we can use c(2n-1,2k)=c(2n,2k-1)=0, c(4n-2,0)=-1, c(4n,0)=1, c(1,1)=1, c(2,2)=2, c(2n+1,k)=2c(2n,k-1)-c(2n-1,k) and c(2n+2,2k)=2c(2n+1,2k-1)-c(2n,2k) to generate the entire array. The triangular array induced from sin(2n-1)A is the same as that induced from cos(2n-1)A except the signs for even n. Let s(2n,k) be the triangular array induced from sin2(n+1)A/cosA. Then s(2n,2n-2k) is a linear combination of c(2n,2n-2k) and c(2n-2,2n-2) with the coefficients only involving powers of 4 and the binomial coefficient C(2n-k-1,k-2). Furthermore, we have s(2n,2k)=s(2n-2,2k)-2(n-k+1)s(2n,2k-2)/k. By writing tan(2n-1)A and tan2nA into rational functions of tanA and considering only nonzero entries, we obtain arrays t, u, v and w from numerators and denominators so that t and u are the same for odd n and differ in signs, where u(n,k)=C(2n-1,2k-2) for even n-k and u(n,k)=-C(2n-1,2k-2) for odd n-k. We also have v(n,k)=C(2n,2k-1) for even k, v(n,k)=-C(2n,2k-1) for odd k, w(n,k)=C(2n,2k) for even k and w(n,k)=-C(2n,2k) for odd k. c and u are also related. (Received May 27, 2009)

1056-11-22 **William A Stein*** (wstein@gmail.com), 1212 East Barclay Court, Seattle, WA 98122. *Gross-Zagier subgroups of elliptic curves over* $\mathbb{Q}$.

I will introduce the notion of Gross-Zagier subgroups of elliptic curves, which are certain subgroups that satisfy the Gross-Zagier formula. I will then give examples and counterexamples about them, state some new results and conjectures, and explain a connection with the Birch and Swinnerton-Dyer conjecture. (Received May 10, 2009)

1056-11-48 **Samuel W Gilbert*** (sw.gilbert@yahoo.com), 8000 Towers Crescent Drive, Suite 1345, Vienna, VA 22182. *The Riemann Hypothesis and the Roots of the Riemann Zeta Function.*

This paper is a study of the geometric convergence of the Dirichlet series representation of the Riemann zeta function at its roots in the critical strip. The objectives are to understand why non-trivial roots occur in the Riemann zeta function and to define the roots mathematically.

The roots of the zeta function are the only points in the critical strip where infinite summation and infinite integration of the Dirichlet series terms are geometrically equivalent. Similarly, the roots of the zeta function with the real part of the argument reflected in the critical strip are the only points where infinite summation and infinite integration of the Dirichlet series terms with reflected argument are geometrically equivalent.

Simplified asymptotic expansions for the Dirichlet series terms of the Riemann zeta function at the roots, equated algebraically with simplified asymptotic expansions for the series terms of the zeta function with reflected argument at the roots, constrain the values of the real parts of both arguments to the critical line. Hence, the Riemann hypothesis is correct. It is also demonstrated that derived formulae yield calculated values of the imaginary parts of the roots of the Riemann zeta function with more than 330 correct significant figures. (Received July 13, 2009)

1056-11-133 **Badih N. Ghusayni*** (`badih@future-in-tech.net`), Dept. of Math., Faculty of Science-1, Lebanese University, Hadath, Lebanon. *The Value of the Zeta Function at an Odd Argument.*

For over 300 years the values of the Zeta function at odd arguments have remained a mystery. The PSLQ algorithm which is implemented in the Computer Algebra System Maple is considered one of the top ten algorithms of the 20th Century. We employ PSLQ to discover an Euler-type identity for an odd argument. A mathematical proof follows the discovery. (Received July 29, 2009)

1056-11-154 **Joseph H. Silverman** and **J. Felipe Voloch*** (`voloch@math.utexas.edu`), Dept. of Mathematics, University of Texas, Austin, TX 78712. *A Local-Global Criterion for Dynamics on $\mathbb{P}^1$.*

Let $K$ be a number field or a one-dimensional function field, let $f : \mathbb{P}^1 \to \mathbb{P}^1$ be a rational map of degree at least two defined over $K$, let $P \in \mathbb{P}^1(K)$ be a point with infinite $f$-orbit, and let $Z \subset \mathbb{P}^1$ be a finite set of points. We will discuss a local-global criterion for the intersection of the $f$-orbit of $P$ and the finite set $Z$ and sketch a proof. This is a special case of a dynamical Brauer–Manin criterion suggested by Hsia and Silverman for more general arithmetic dynamical systems. (Received August 05, 2009)

1056-11-171 **Alejandra Alvarado*** (`devina21@hotmail.com`), 2514 E. 23rd St., Tucson, AZ 85713. *Arithmetic Progressions on Curves of Degree Five.*

Let $f$ be a degree five polynomial over the rationals. Consider the curve $y^2 = f(x)$. We will show that there is an infinite family of such curves which contain an arithmetic progression of length 12. (Received August 11, 2009)

1056-11-193 **Kimberly Hopkins*** (`khopkins@math.utexas.edu`), The University of Texas at Austin, Department of Mathematics, C1200, Austin, TX 78712. *A partial generalization of the Gross-Kohnen-Zagier theorem to higher weight modular forms.*

In the paper, 'Heegner points and derivatives of L-series II', Gross, Kohnen, and Zagier proved a seminal result relating the positions of Heegner divisors on a line in the Jacobian of the modular curve to Fourier coefficients of half-integer weight modular forms. We formulate a conjecture which partially generalizes their theorem to higher weight modular forms, and present our current results towards its proof. (Received September 18, 2009)

1056-11-197 **Ekin Ozman*** (`ozman@math.wisc.edu`). *What is a $\mathbb{Q}$ curve?*

A $\mathbb{Q}$-curve is an elliptic curve which is isogenous to all of its Galois conjugates. It is a mild generalization of an elliptic curve and has many interesting applications such as twisted Fermat type equations. A quadratic $\mathbb{Q}$-curve is a $\mathbb{Q}$-curve for which the smallest field of definition is a quadratic field. Quadratic $\mathbb{Q}$-curves of degree $N$ defined over $\mathbb{K} = \mathbb{Q}(\sqrt{d})$ are parametrized by $X_0^d(N)$, the twist of $X_0(N)$ via $w_N$ and the generator of the Galois group of $\mathbb{K}$ over $\mathbb{Q}$. Since cusps of $X_0(N)$ are rational it is immediate to say that $X_0(N)(\mathbb{Q})$ is non-empty. But $w_N$ interchanges the cusps of $X_0(N)$ hence cuspidial points of the twist are not rational anymore. So it is not immediate to say if $X_0^d(N) = \emptyset$ or not. We will give an answer to the following question which is stated by Ellenberg:

*For which $\mathbb{K}$ and $N$ does $X_0^d(N)$ have rational points over every completion of $\mathbb{Q}$?* (Received August 14, 2009)

1056-11-200 **Maosheng Xiong*** (`xiong@math.psu.edu`), 210 McAllister BLD, Dept. Mathematics, Eberly College of Science, Penn State University, State College, PA 16802. *The fluctuations in the number of points on a family of curves over a finite field.*

Let $p$ be a prime number, $\mathbb{F}_q$ a finite field of cardinality $q$ with $q \equiv 1 \pmod{p}$. In this paper we study the fluctuations in the number of $\mathbb{F}_q$-points on the curve $C_F$, namely $\#C_F(\mathbb{F}_q)$, with affine model $C_F : Y^p = F(X)$, where $F$ is drawn at random uniformly from the set of all irreducible polynomials $F \in \mathbb{F}_q[X]$ of degree $d$. For $q$ fixed and $d \to \infty$, we find that the limiting distribution of $\#C_F(\mathbb{F}_q) - 1 - q$ is that of a sum of $q$ i.i.d. random variables taking the values $-1, p-1$ with probabilities $\left(\frac{p-1}{p}, \frac{1}{p}\right)$ respectively. When both $d, q \to \infty$, we find that $\frac{\#C_F(\mathbb{F}_q)-1-q}{\sqrt{q(p-1)}}$ has a standard Gaussian distribution. (Received August 14, 2009)

1056-11-292 **Dragos Ghioca***, Department of Mathematics & Computer Science, University of Lethbridge, 4401 University Drive, Lethbridge, Alberta T1K 3M4, Canada. *The dynamical Manin-Mumford problem.*

We discuss Zhang's dynamical Manin-Mumford conjecture. We present a family of counterexamples, and then we propose a reformulation of the conjecture which takes into account our family of counterexamples. Then we prove our reformulation for endomorphisms of abelian varieties, and for split endomorphisms of $\mathbb{P}^1 \times \mathbb{P}^1$. This work is joint with Thomas J. Tucker. (Received August 26, 2009)

1056-11-308 **Kevin J McGown*** (kmcgown@math.ucsd.edu), Department of Mathematics, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA 92093-0112. *Euclidean Prime Degree Galois Number Fields.* Preliminary report.

Let $K$ be a Galois number field of prime degree $\ell$. Heilbronn has shown that for a given $\ell$ there are only finitely many such fields that are Euclidean with respect to the norm map. In the case of $\ell = 2$ all such norm-Euclidean fields have been classified, but for $\ell \neq 2$ not much else is known. We give, for the first time, upper bounds on the discriminants of such fields when $\ell > 2$. Our methods lead to a simple algorithm which allows one to generate a list of candidate norm-Euclidean fields up to a given discriminant. (Received August 27, 2009)

1056-11-337 **Moshe Adrian*** (madrian@math.umd.edu). *Revisiting the Local Langlands Correspondence for GL(n,F), n a prime.*

The Local Langlands Correspondence for GL(n) has been proven recently by Henniart,Harris/Taylor. In the tame case, supercuspidal representations correspond to characters of elliptic tori, but the local Langlands correspondence is unnatural because it involves a twist by some character of the torus. Taking the cue from the theory of real groups, supercuspidal representations should instead be parameterized by characters of covers of tori. DeBacker has calculated the distribution characters of supercuspidal representations for GL(n), n prime, and they are written in terms of functions on elliptic tori. Over the reals, Harish-Chandra parameterized discrete series representations of real groups by describing their distribution characters. Those distribution characters are written down in terms of functions on covers of real tori. I have succeeded in showing that if one writes down a natural analogue of Harish-Chandra's distribution character for p-adic groups, it is the character of a unique supercuspidal representation of GL(n), where n is prime, far away from the identity. These results pave the way for a new statement of the local Langlands correspondence for GL(n), n prime. In particular, there is no need to introduce any character twists. (Received September 01, 2009)

1056-11-343 **Yufei Zhao*** (yufeiz@mit.edu), 3 Ames St, #10, Cambridge, MA 02142. *More Sums than Differences Sets and Beyond.*

A more sums than differences (MSTD) set is a finite subset $S$ of integers such that $|S+S| > |S-S|$. We present some new results on MSTD subsets of $\{0, 1, \dots, n\}$ that address the following two questions: (1) what proportion of the subsets are MSTD sets? (2) what does a typical MSTD set look like?

In general, our results work for any specification on the number of missing sums and the number of missing differences of $S$, with MSTD sets being a special case. (Received August 31, 2009)

1056-11-346 **John Voight*** (jvoight@gmail.com), Department of Mathematics and Statistics, University of Vermont, 16 Colchester Ave, Burlington, VT 05401. *The Gauss higher relative class number problem.*

We generalize Gauss' problem of determining all imaginary quadratic fields of small class number to the case of the higher relative class numbers of CM fields. These class numbers appear in the formula for certain special values of the L-function associated to such a CM extension. Assuming the 2-adic Iwasawa main conjecture, we find all CM fields with higher relative class number at most 16: there are at least 31 and at most 34 such fields, and exactly one is not abelian. (Received September 01, 2009)

1056-11-360 **Yakov I Berchenko-Kogan*** (yashabk@caltech.edu), 1200 E California Blvd, MSC 134, Pasadena, CA 91126. *Minimal product sets sizes in nonabelian groups.*

For a group $G$ and integers $r$ and $s$, we consider $\mu_G(r,s)$, the minimum cardinality of the product set $AB$, where $A$ and $B$ are subsets of $G$ of cardinality $r$ and $s$, respectively. We compute $\mu_G$ for all nonabelian groups of order $pq$, where $p$ and $q$ are distinct odd primes, thus proving a conjecture of Deckelbaum. In addition, we apply a theorem of Eliahou and Kervaire to compute $\mu_G$ for all groups of order $p^3$, where $p$ is a prime. (Received September 01, 2009)

1056-11-361 **Jonathan Lubin*** (lubinj@math.brown.edu), 626 N Michigan Ave, Pasadena, CA 91106-1135. *Torsion points of higher order in the Nottingham group.* Preliminary report.

If $k$ is a finite field of characteristic $p$, then the set of formal series of the form $x + a_1x^2 + a_2x^3 + \cdots$ is a group under compostion, often called the Nottingham group over $k$; we denote it $N(k)$. It is a pro-$p$-group, and it is known that every finite $p$-group may be embedded in it. The torsion elements of $N(k)$ of order $p$ are easy both to classify and to describe, but explicit constructions of elements of order $p^m$ with $m > 1$ have not been well known.

In this talk I will point out that standard constructions in the theory of formal groups in characteristic zero give infinitely many nonconjugate torsion elements of $N(k)$ of any arbitrarily high order, but that these are very special among all torsion elements. Then I will sketch a construction that has nothing to do with the preceding method, but instead uses simple considerations of local class-field theory in characteristic $p$ to give a coarse classification of all torsion elements of $N(k)$, and a way of approaching the much more difficult question of a complete classification up to conjugacy. (Received September 02, 2009)

1056-11-365 **John T Cullinan*** (cullinan@bard.edu), Department of Mathematics, Bard College, Annandale-On-Hudson, NY 12504. *Ramification in iterated towers for rational functions.*

Let $\phi(x)$ be a rational function of degree $d > 1$ defined over a number field $K$ and let $\Phi_n(x,t) = \phi^{(n)}(x) - t \in K(x,t)$ where $\phi^{(n)}(x)$ is the $n$th iterate of $\phi(x)$. We give a formula for the discriminant $D_{n,\phi}(t)$ of the numerator of $\Phi_n(x,t)$ and show that, if $\phi(x)$ is postcritically finite, for each specialization $t_0$ of $t$ to $K$, there exists a finite set $S_{t_0}$ of primes of $K$ such that for all $n$, the primes dividing $D_{n,\phi}(t_0)$ are contained in $S_{t_0}$. This is joint work with Farshid Hajir. (Received September 02, 2009)

1056-11-373 **Cristian D Popescu*** (cpopescu@math.ucsd.edu), University of California, San Diego, Department of Mathematics, Dept 0112, La Jolla, CA 92093-0112. *Tate sequences and applications.* Preliminary report.

We use our recent joint work with Greither on $\ell$–adic realizations of 1–motives to construct some concrete perfect complexes which conjecturally belong to the Tate canonical class in a certain Ext-group associated to an arbitrary Galois extension of global fields (in particular, function fields). We indicate how the Grothendieck determinants of these complexes can be computed in terms of special values of global L-functions. We show how these constructions lead to proofs of some classical conjectures on special values of global L-functions. (Received September 02, 2009)

1056-11-376 **Vorrapan Chandee*** (vchandee@math.stanford.edu), Department of Mathematics, Stanford University, 450 Serra Mall, Building 380, Stanford, CA 94305. *Explicit Upper Bounds for L-functions on the critical line.*

We find an explicit upper bound for general $L$-functions on the critical line, assuming the Generalized Riemann Hypothesis, and give as illustrative examples its application to some families of $L$-functions and Dedekind zeta functions. Further, this upper bound is used to obtain lower bounds beyond which all eligible integers are represented by Ramanujan's ternary form. This improves on previous work of Ono and Soundararajan with a substantially easier proof. (Received September 02, 2009)

1056-11-377 **Yoonjin Lee*** (yoonjinl@ewha.ac.kr), Department of Mathematics, Ewha Womans University, 11-1 Daehyun-Dong, Seodaemun-Gu, Seoul, 120-750, South Korea. *The Reflection Theorem for class groups of global function fields and its applications.*

We present the Reflection Theorem for divisor or ideal class groups of global function fields. In detail, let $K$ be a global function field with constant field $F_q$, $L_1$ a quadratic geometric extension of $K$ and $L_2$ its twist by the quadratic constant field extension of $K$. We show that for every odd integer $m$ dividing $q + 1$, the divisor class groups of $L_1$ and $L_2$ have the same $m$-rank, while their $m$-ranks of ideal class groups are equal or differ by 1. We then discuss its applications to other related results. We also present complete descriptions for relative quadratic function fields whose class numbers are divisible by 3. (Received September 03, 2009)

1056-11-384 **Alexandru Buium*** (buium@math.unm.edu), Department of Mathematics and Statistics, University of New Mexico, Albuquerque, NM 87131. *Groups defined by arithmetic differential equations.*

Groups defined by algebraic differential equations (differential algebraic groups) were introduced by Cassidy and Kolchin. Their study is intertwined with diophantine problems over function fields. On the other hand one can consider an arithmetic analogue of differential equations in which the derivative operator is replaced by a Fermat quotient operator. Correspondingly one may consider groups defined by arithmetic differential equations and study their properties with an eye on applications to diophantine problems over number fields. The talk is devoted to explaining this circle of ideas. (Received September 03, 2009)

1056-11-430 **Dae San Kim*** (dskim@sogang.ac.kr), Department of Mathematics, Sogang University, Seoul, 121-742, South Korea. *An Infinite Family of Recursive Formulas Generating Power Moments of Kloosterman Sums with Trace One Arguments: $O(2n+1,2^r)$ Case.*

In this paper, we construct an infinite family of binary linear codes associated with double cosets with respect to certain maximal parabolic subgroup of the orthogonal group $O(2n+1,q)$. Here $q$ is a power of two. Then we obtain an infinite family of recursive fomulas generating the odd power moments of Kloosterman sums with trace one arguments in terms of the frequencies of weights in the codes associated with those double cosets in $O(2n+1,q)$ and in the codes associated with similar double cosets in the symplectic group $Sp(2n,q)$. This is done via Pless power moment identity and by utilizing the explicit expressions of exponential sums over those double cosets related to the evaluations of "Gauss sums" for the orthogonal group $O(2n+1,q)$. (Received September 06, 2009)

1056-11-431 **Matthew Papanikolas*** (map@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843. *Values of Goss L-functions for Dirichlet characters at positive integers.* Preliminary report.

We will discuss values of Goss $L$-functions at positive integers and their relations to many prominent quantities in function field arithmetic. Let $\mathbf{F}_q[\theta]$ be a polynomial ring over the finite field with $q$ elements, and let $\chi : \mathbf{F}_q[\theta] \to \overline{\mathbf{F}}_q$ be a Dirichlet character. For a positive integer $n$, special values of the Goss $L$-series for $\chi$ are defined by the series

$$L(n,\chi) = \sum_{a \in \mathbf{F}_q[\theta],\ \text{monic}} \frac{\chi(a)}{a^n},$$

which converges in the Laurent series field $\overline{\mathbf{F}}_q((1/\theta))$. In 1990 Anderson and Thakur considered the case of Carlitz-Goss zeta values, and showed that these values can be expressed as coordinates of logarithms on tensor powers of the Carlitz module. In 1996, Anderson considered additional characters and showed that $L(1,\chi)$ can be expressed in terms of logarithms of special points on the Carlitz module itself. We will show how to extend Anderson's log-algebraicity methods to tensor powers of the Carlitz module. Using this we find new formulas, which are explicitly related to the Carlitz period and Carlitz polylogarithms, for values of Goss $L$-functions at all positive integers. (Received September 06, 2009)

1056-11-442 **Matilde N Lalin*** (mlalin@math.ualberta.ca), University of Alberta, Department of Mathematical and Statistical Sc, 632 CAB, Edmonton, Alberta T6G 2G1, Canada. *Higher Mahler measures.*

The classical Mahler measure of an $n$-variable polynomial $P$ is the integral of $\log|P|$ over the $n$-dimensional unit torus $\mathbb{T}^n$ with the Haar measure. We consider, more generally, the integral of $\log^k|P|$. Specific examples yield special values of zeta functions, Dirichlet L-series, and polylogarithms. This is a joint work with N. Kurokawa and H. Ochiai. (Received September 07, 2009)

1056-11-470 **Pete L. Clark*** (pete@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30606. *Anti-Hasse Principles for Algebraic Curves.*

I will describe recent work on the systematic construction of algebraic curves over global fields which violate the Hasse Principle. (Received September 08, 2009)

1056-11-500 **Jorge F Sawyer*** (sawyerj@lafayette.edu), Box 8681, 111 Quad Dr., Easton, PA 18042, and **Clifford A Reiter** (reiterc@lafayette.edu), Dept of Mathematics, Easton, PA 18042. *Perfect Parallelepipeds Exist.*

There are parallelepipeds with edge lengths, face diagonal lengths and body diagonal lengths all positive integers. In particular, there is a parallelepiped with edge lengths 271, 106, 103, minor face diagonal lengths 101, 266, 255, major face diagonal lengths 183, 312, 323, and body diagonal lengths 374, 300, 278, 272. Searches for perfect parallelepipeds led to configurations satisfying necessary quadratic diophantine equations but which are not realizable in $\Re^3$; realizable configurations satisfy an additional sixth degree inequality. Brute force searches also give primitive perfect parallelepipeds with some some rectangular faces. (Received September 10, 2009)

1056-11-522 **David Whitehouse*** (dw@math.mit.edu), Department of Mathematics, MIT, 2-171, 77 Massachusetts Avenue, Cambridge, MA 02139. *Periods and central values of quadratic base change L-functions.*

An important result of Waldspurger relates the central value of quadratic base change L-functions for GL(2) to period integrals over tori. Subsequently this result was reproved by Jacquet using the relative trace formula. We will explain some progress on extending Waldspurger's result to higher rank via a generalization of Jacquet's approach. (Received September 11, 2009)

1056-11-538 **Michael J. Daniel*** (mjd85@drexel.edu), 3141 Chestnut St., Korman 206, Philadelphia, PA 19104. *Fourier Coefficients, Relations, and Ranks in the Space of Eisenstein Series of a Function Field of a Finite Field.*

The author extends the classical results about Fourier coefficients of Eisenstein series over $\mathbb{Q}$ to the setting of a function field of a finite field. Using algebraic methods and harmonic analysis, especially the technique of Poisson summation, the author computes Fourier coefficients of Eisenstein series for both the full modular group and congruence subgroups. Using the results for the full modular group, relations between Eisenstein series and ranks of the spaces of Eisenstein series of various integral weights can be computed. (Received September 11, 2009)

1056-11-555 **Clayton Petsche*** (cpetsche@hunter.cuny.edu), **Lucien Szpiro** and **Thomas J. Tucker**. *A Dynamical Pairing Between Two Rational Maps.*

Given two rational maps $\varphi$ and $\psi$ on $\mathbb{P}^1$, with each map defined over a number field and having degree at least two, we study a symmetric, nonnegative-real-valued pairing $\langle\varphi, \psi\rangle$ which is closely related to the canonical height functions $h_\varphi$ and $h_\psi$ associated to these maps. Our main results show a strong connection between the value of $\langle\varphi, \psi\rangle$ and the canonical heights of points which are small with respect to at least one of the two maps $\varphi$ and $\psi$. Several necessary and sufficient conditions are given for the vanishing of $\langle\varphi, \psi\rangle$. We give an explicit upper bound on the difference between the canonical height $h_\psi$ and the standard height $h$ in terms of $\langle\sigma, \psi\rangle$, where $\sigma(x) = x^2$ denotes the squaring map. The pairing $\langle\sigma, \psi\rangle$ is computed or approximated for several families of rational maps $\psi$. (Received September 12, 2009)

1056-11-563 **Thomas J Tucker*** (tjtucker@gmail.com), Math Dept, University of Rochester, Rochester, NY 14610, and **Dragos Ghioca** and **Shouwu Zhang**. *The dynamical Manin-Mumford problem.*

We present counterexamples to the simplest formulation of a dynamical Manin-Mumford theorem, suggest possible modifications, and describe a series of results on rational functions giving the same canonical height (this may be viewed as a special case of the conjecture). (Received September 12, 2009)

1056-11-568 **Liang-Chung Hsia*** (hsia@math.ncu.edu.tw), Department of Mathematics, National Central University, No.300, Jhongda Rd., Jhongli City, Taoyuan County, 32001, Taiwan. *On dynamical zeta functions for polynomial maps over p-adic fields.* Preliminary report.

In the study of dynamical systems, the set of periodic points carry important information of the dynamics. In analgous to the Hasse-Weil zeta function in number theory, a zeta function was proposed by Artin and Mazur to count the set of isolated periodic points of the dynamics arizing from diffeomorphisms of compact manifolds.

The Artin-Mazur zeta function is the function that we want consider for dynamics over $p$-adic fields. In this talk, we'll give a definition for zeta function of dynamics over $p$-adic field. Some of its properties will be discussed and especially, we will be concerned with whether or not it is a rational function. Zeta functions for a family of polynomail maps over a $p$-adic field will be presented. (Received September 13, 2009)

1056-11-570 **Yoonbok Lee*** (leeyb@yonsei.ac.kr), Department of Mathematics, Yonsei University, 134 Shinchon-dong Seodaemun-gu, Seoul, 120-749, South Korea. *On the zeros of Epstein zeta functions.*

We investigate the zeros of Epstein zeta function associated with a positive definite quadratic form with integral coefficients which corresponds to an imaginary quadratic form with class number bigger than 1. Davenport and Heilbronn, and Voronin proved the presence of its zeros off the critical line. In this talk, we present the improvement of their results. In precise, the number of its zeros in $\sigma_1 < \Re s < \sigma_2$, $0 < \Im s < T$ is $cT + o(T)$ for $\frac{1}{2} < \sigma_1 < \sigma_2$, and the constant $c = c(\sigma_1, \sigma_2)$ is positive for $\sigma_2 < 1$. (Received September 13, 2009)

1056-11-575 **Benjamin Hutz*** (bhutz@amherst.edu), Department of Mathematics, Amherst College Box 2239, P.O. 5000, Amherst, MA 01002. *On the Number of Rational Pre-Images Under Quadratic Dynamical Systems.*

We study the number of rational pre-images of a rational number $a$ under the quadratic polynomial map $f_c(x) = x^2 + c$. We state the existence of a uniform bound (uniform over the family of maps $f_c(x)$) on the number of rational pre-images and examine effective bounds for various choices of $a$. We use methods from rational points on curves, Falting's Theorem, height functions, elliptic curves, and elliptic surfaces. This is a combination of completed work, work in progress, and supervised student research. (Received September 13, 2009)

1056-11-631 **Chad Awtrey*** (awtrey@asu.edu). *Galois theory for tame dodecic local fields.*

Given a monic irreducible degree 12 polynomial $f(X) \in \mathbf{Z}_p[X]$ and a prime number $p \geq 5$, let $K/\mathbf{Q}_p$ be the splitting field of $f$ and $G$ its Galois group. Based on the theory of higher ramification groups, we discuss an original algorithm for identifying $G$ from among the 301 possible transitive subgroups of $S_{12}$. (Received September 15, 2009)

1056-11-641 **Andrew H. Knightly***, Department of Mathematics & Statistics, 333 Neville Hall, University of Maine, Orono, ME 04469-5752, and **Charles Li**, Department of Mathematics, Chinese University of Hong Kong. *The relative trace formula and average values of L-functions.*

I will discuss some applications of the relative trace formula to averages of modular L-values. (Received September 15, 2009)

1056-11-658 **Robert L. Benedetto*** (rlb@math.amherst.edu), Department of Mathematics, Amherst College, Amherst, MA 01002. *Towards Dynamical Uniform Boundedness for Rational Functions.* Preliminary report.

Let $K$ be a number field, and let $\phi$ be a morphism from the projective line to itself, defined over $K$ and of degree at least two. The 1994 Uniform Boundedness Conjecture of Morton and Silverman claims, in dimension one, that the number of $K$-rational preperiodic points of $\phi$ is bounded by a constant depending only on the degrees of $\phi$ and $K$. In recent years, some progress has been made towards the conjecture in the case that $\phi$ is a polynomial. In this talk, we will consider the case that $\phi$ is a non-polynomial morphism. (Received September 15, 2009)

1056-11-659 **Robert L. Benedetto*** (rlb@math.amherst.edu), Department of Mathematics, Amherst College, Amherst, MA 01002. *An $N$-point version of the Mason-Stothers abc Theorem.*

We will interpret the *abc* theorem of Mason and Stothers as a statement about four points in the projective line. We will then consider generalizations for more than four points, using local terms arising from graphs in Berkovich space. (Received September 15, 2009)

1056-11-664 **Xander Faber*** (xander@math.mcgill.ca), McGill University, Department of Mathematics and Statistics, 805 Sherbrooke St. West, Montreal, Quebec H3A 2K6, Canada. *Critical Points of Non-Archimedean Dynamical Systems on the Projective Line.* Preliminary report.

I will discuss a collection of results on the ramification loci of rational maps over Non-Archimedean fields. (Received September 15, 2009)

1056-11-666 **Kaneenika Sinha*** (kaneenik@ualberta.ca), Department of Mathematics, University of Alberta, Edmonton, Alberta T6G2G1, Canada. *Ranks of Jacobians of modular curves.*

Let $J_0(N)$ denote the Jacobian variety of the modular curve $X_0(N)$. We obtain upper bounds on ranks of these abelian varieties using arithmetic information about Fourier coefficients of newforms of weight 2 and level $N$. (Received September 15, 2009)

1056-11-668 **David Goss*** (goss@math.ohio-state.edu). *Symmetries of characteristic $p$ L-series.*

Let $p$ be a prime number with $\mathbf{Z}_p$ the ring of $p$-adic integers. As is universally known, every $p$-adic number $s$ may be written as $s = \sum_{i=0}^{\infty} c_i p^i$ where $0 \leq c_i < p$ for all $i$. By simply permuting these digits $\{c_i\}$ in a consistent fashion for all $s \in \mathbf{Z}_p$ we obtain a group of homeomorphisms of $\mathbf{Z}_p$ which we call $S_{Z(p)}$. This group is easily seen to have the cardinality of the continuum. In this talk we will explain the evidence that $S_{(p)}$ acts as symmetries of characteristic $p$ valued $L$-series arising in theory of Drinfeld modules, $t$-modules, and various generalizations. The evidence comes from special values at both the positive and negative integers of these functions. (Received September 15, 2009)

1056-11-677 **J Brian Conrey*** (conrey@aimath.org), American Insttute of Mathematics, 360 Portage Ave., Palo Alto, CA 94306. *Critical zeros of Dirichlet L-functions.* Preliminary report.

It is known that at least 40.88% of the zeros of the Riemann zeta-function are on the critical line.

In joint work with Iwaniec and Soundararajan we prove a lower bound for zeros of Dirichlet $L$-functions on the critical line. Specifically, let $Q$ be a large parameter. Consider all of the primitive Dirichlet characters $\chi$ modulo $q$ where $q \leq Q$, all of the associated $L$-functions $L(s, \chi)$ and all of the zeros of all of these $L(s, \chi)$ in the critical strip up to height $\log Q$. We show that at least $x$ percent of the collection of all of these zeros are on the critical line, i.e. have real parts equal to 1/2, where $x$ is a number that will be revealed during the talk. (Hint: $x > 40.88$.) (Received September 15, 2009)

1056-11-697 **Radoslav M Kirov*** (rkirov2@illinois.edu), Department of Mathematics, 1409 W. Green Street, Urbana, IL 61801, and **Iwan M Duursma** (duursma@math.uiuc.edu), Department of Mathematics, 1409 W. Green Street, Urbana, IL 61801. *Arithmetic of Curves and Error-Correction.*

Using a construction due to Goppa, algebraic curves can be used to produce error-correcting codes. A method of Feng-Rao and its generalization - the order bound - have been successful in obtaining bounds for the distances of such codes. We translate those methods to an arithmetic geometry setting and generalize them. We define certain semigroups of base point free divisors classes, which capture the supports of subsets of words in the code. Our main theorem gives a computational algorithm to get bounds on those semigroups using only intrinsic properties of Riemann-Roch spaces. Explicit applications of our method to Hermitian curves are presented. (Received September 16, 2009)

1056-11-751 **Barry R. Smith*** (bsmith@math.uci.edu), 340 Rowland Hall, Irvine, CA 92697-3875. *Divisibility properties of values of partial zeta functions at non-positive integers.* Preliminary report.

The values of the partial zeta functions for an abelian extension of number fields at non-positive integers are rational numbers with known bounds on their denominators. I will discuss a new conjecture that provides sharper bounds and consider conditions under which the conjecture is valid. (Received September 16, 2009)

1056-11-757 **Renate Scheidler*** (rscheidl@math.ucalgary.ca), Department of Mathematics and Statistics, University of Calgary, 2500 University Drive NW, Calgary, Alberta T2N 1N4, Canada, and **Qingquan Wu**. *Ramification Groups and Differents in Artin-Schreier Composita.*

Let $K$ be a function field over a perfect constant field of positive characteristic $p$, and $L$ the compositum of $n$ (degree $p$) Artin-Schreier extensions of $K$. Then much of the bahaviour of the degree $p^n$ extension $L/K$ is determined by the bahaviour of the (well understood) degree $p$ intermediate extensions $M/K$. For example, a place of $K$ totally ramifies/is inert/splits completely in $L$ if and only if it totally ramifies/is inert/splits completely in every $M$, and all possible decompositions are indeed possible. All the different exponents in $L/K$ are also given by those in all the $M/K$, and similar results hold for the genus, the regulator, the ideal class number and the divisor class number. In the case $n = 2$, it is also possible to provide an explicit description of the ramification group filtration; an extension of this result to arbitrary $n$ (and in fact to elementary Abelian $p$ extensions that need not be Artin-Schreier) is currently in progress. (Received September 16, 2009)

1056-11-789 **Ethan C. Smith*** (ethans@mtu.edu), Mathematical Sciences, Michigan Technological University, 1400 Townsend Drive, Houghton, MI 49931, and **Kevin James** (kevja@clemson.edu), Mathematical Sciences, Clemson University, Box 340975, Clemson, SC 29634-0975. *Average Frobenius distribution for elliptic curves defined over number fields.*

Given an integer $r$ and an elliptic curve $E$, the fixed trace Lang-Trotter Conjecture concerns the number of primes $p$ up to $x$ with trace of Frobenius $a_p(E)$ equal to $r$. In this talk, we will discuss a generalization of the conjecture to the setting of number fields and a result that says this conjecture is true "on average" when the number field is Galois over the rationals. A key ingredient in the proof is the computation of a certain weighted sum of special values of Dirichlet $L$-functions. This work builds on previous papers by Fouvry and Murty, David and Pappalardi, and recently by Faulkner, James, King, and Penniston. This is joint work with Kevin James. (Received September 17, 2009)

1056-11-790 **Jonathan W. Bayless*** (BaylessJ@husson.edu), Mathematics Department, Husson University, One College Circle, Bangor, ME 04401, and **Dominic Klyve**. *On the sum of the reciprocals of the amicable numbers.* Preliminary report.

Two numbers $m$ and $n$ are considered amicable if the sum of their proper divisors, $s(m)$ and $s(n)$, satisfy $s(m) = n$ and $s(n) = m$. In 1981, Pomerance showed that the sum of the reciprocals of all such numbers, $P$, is a constant. We obtain both a lower and an upper bound on the value of $P$. (Received September 17, 2009)

1056-11-802 **Jennifer Beineke**, **Ben Brubaker** and **Sharon Frechette*** (sfrechet@mathcs.holycross.edu). *Weyl Group Multiple Dirichlet Series.* Preliminary report.

We extend the theory of "Weyl group multiple Dirichlet series" to root systems of type $C$. These are Dirichlet series in several complex variables with analytic continuation and functional equations isomorphic to the associated Weyl group. They conjecturally come from the Fourier-Whittaker coefficients of minimal parabolic Eisenstein series on a metaplectic cover of $SO(2r + 1)$. We give a construction for an infinite family of Dirichlet series in several variables with the above conjectured analytic properties, using bases for certain highest weight representations of $Sp(2r)$ parametrized by Gelfand-Tsetlin patterns. We then prove portions of this conjecture in two important special cases. One case uses the Casselman-Shalika formula for unramified principal series and a deformation of the Weyl character formula of Hamel and King. The other relates our definition to an alternate description of multiple Dirichlet series proposed by Brubaker, Bump, and Friedberg. (Received September 17, 2009)

1056-11-823 **Helen G Grundman*** (grundman@brynmawr.edu), Department of Mathematics, Bryn Mawr College, 101 N. Merion Ave., Bryn Mawr, PA 19010. *Solutions to* $xyz = x + y + z = 1$ *in algebraic integers of bounded degrees.* Preliminary report.

Several papers have considered the problem of finding, for a fixed $n \in \mathbf{Z}^+$, all integral solutions to $xyz = x + y + z = 1$ contained in fields of degree $n$ over $\mathbf{Q}$. Complete results are known for $n \leq 4$, but only partial results are known for $n = 5$. In particular, it is not known (or even conjectured) that, for $n = 5$, all of the solutions have been found.

In this talk, I will summarize the earlier findings for $n \leq 5$ and then discuss more recent work that has led to the discovery of further solutions to the equation in the quintic field case. I will also discuss the remaining roadblocks to completely solving the problem in this case. (Received September 17, 2009)

1056-11-824 **Kimberly Hopkins*** (khopkins@math.utexas.edu), Univeristy of Texas at Austin, Department of Mathematics, C1200, Austin, TX 78712. *Higher weight Heegner points.*

We formulate a conjecture which partially generalizes the Gross-Kohnen-Zagier theorem to higher weight modular forms. This involves constructing higher weight analogues of Heegner divisors on a certain complex torus defined by the periods of a modular form. We will present some of our current results and progress towards its proof. (Received September 17, 2009)

1056-11-831 **Michelle Manes*** (mmanes@math.hawaii.edu), Department of Mathematics, University of Hawaii, 2565 McCarthy Mall, Keller 401A, Honolulu, HI 96822, and **Rafe Jones**. *Galois theory of quadratic rational functions with a non-trivial automorphism.* Preliminary report.

Let $f$ be a degree-2 rational function defined over a number field $K$ commuting with an involution $i \in \mathrm{PGL}_2$, and let $P \in \mathbb{P}^1$ be a fixed point of $i$. In this talk, we consider the Galois action on the rooted binary tree of preimages of $P$ under $f$. We suggest conditions under which the image of Galois in the automorphism group of the tree is as large as possible, drawing parallels to Serre's finite-index theorem for representations in the CM elliptic curve case. (Received September 17, 2009)

1056-11-844 **Syrous Marivani*** (smarivani@lsua.edu), LSUA, MAPS Dept., 8100 HWY 71S, Alexandria, LA 71360. *An elementary Proof of a Ramanujan's Congruence Identity.*

In this paper I give an elementary proof of Ramanujan's congruence identity for the partition function mod 11. (Received September 17, 2009)

1056-11-858 **Qingquan Wu*** (quwu@ucalgary.ca), Department of Mathematics and Statistics, University of Calgary, 2500 University Dr NW, Calgary, AB T2N 1N4, Canada. *Explicit construction of integral bases of radical function fields.*

A construction to find an integral basis for a radical function field of equation $y^n = D$ (such that the characteristic does not divide $n$) is described, where the basis is given explicitly in terms of the squarefree factorization of $D$.

Moreover, the $P$-signatures for such a function field are analyzed, and it is discussed when the signature can be written down knowing a few easily computable invariants of the function field.

These results are of interest for two reasons: First, radical function fields are a wide class of function fields. Second, explicit formulae giving a nice integral basis are important for many algorithms for function fields. In particular, the property that these bases are nicely constructed allows optimizations resulting in speed-ups.
(Received September 19, 2009)

1056-11-859 **Lenny Jones*** (lkjone@ship.edu), Department of Mathematics, Shippensburg University, 1871 Old Main Drive, Shippensburg, PA 17257. *Generalizing a Theorem of Sierpiński Using Lucas Sequences.* Preliminary report.

In 1960, Sierpiński proved that there exist infinitely many odd positive integers $k$ such that $k \cdot 2^n + 1$ is composite for all positive integers $n$. In this talk, we investigate generalizations of this result with $2^n$ replaced by expressions involving certain Lucas sequences. (Received September 18, 2009)

1056-11-936 **Sam Elder*** (same@caltech.edu), MSC 385, Pasadena, CA 91126. *Flat Cyclotomic Polynomials: A New Approach.*

The *height* of a polynomial is its greatest coefficient in absolute value. Polynomials of unit height are *flat*. The *cyclotomic polynomial* $\Phi_n(x)$ is the minimal polynomial of any primitive $n$th root of unity. The *order* of $\Phi_n(x)$ is the number of distinct odd primes dividing $n$. All cyclotomic polynomials of orders 0, 1 and 2 are flat, and some of orders 3 and 4 are flat as well.

In this paper, we build a new theory for analyzing the coefficients of $\Phi_n(x)$ by considering it as a gcd of simpler polynomials. We first obtain a generalization of a result known as periodicity: If $n$ is a positive integer and $s$ and $t$ primes such that $n - \varphi(n) < s < t$ and $s \equiv \pm t \pmod{n}$, then $\Phi_{ns}(x)$ and $\Phi_{nt}(x)$ have the same height.

We also use this theory to provide two new families of flat cyclotomic polynomials. One, of order 3, was conjectured by Broadhurst: Let $p < q < r$ be primes and $w$ a positive integer such that $r \equiv \pm w \pmod{pq}$, $p \equiv 1 \pmod{w}$ and $q \equiv 1 \pmod{wp}$. Then $\Phi_{pqr}(x)$ is flat. The other is the first general family of order 4. We prove that $\Phi_{pqrs}(x)$ is flat for primes $p, q, r, s$ where $q \equiv -1 \pmod{p}$, $r \equiv \pm 1 \pmod{pq}$, and $s \equiv \pm 1 \pmod{pqr}$.
(Received September 18, 2009)

1056-11-939 **Brian C. Dietel*** (dietelb@math.oregonstate.edu), Department of Mathematics, Oregon State University, Corvallis, OR 97331. *Bounds on the order function of certain p-adic numbers.*

The order function $O^*$ was introduced by Mahler and places a partial order on the set of complex numbers based on approximation by algebraic numbers. We consider the analogue of the function $O^*$ on the $p$-adic numbers. In particular, we construct numbers in $\mathbb{C}_p$ for which it is possible to obtain upper and lower bounds for $O^*$. Given any function that satisfies certain growth conditions we then use a specific case of this result to construct elements of $\mathbb{C}_p$ for which $O^*$ is equivalent to the original function. (Received September 18, 2009)

1056-11-956 **Eric S. Rowland*** (erowland@tulane.edu), Mathematics Department, Tulane University, New Orleans, LA 70118. *The number of nonzero binomial coefficients modulo $p^\alpha$.*

In 1947 Nathan Fine used Lucas' theorem to compute the number $a_p(n)$ of binomial coefficients $\binom{n}{m}$, $0 \leq m \leq n$, that are not divisible by a prime $p$: If $n_l \cdots n_1 n_0$ is the standard base-$p$ representation of $n$, then $a_p(n) = \prod_{i=0}^{l}(n_i + 1)$.

One can set up (using generating functions, for example) a recursive algorithm to compute for a given $n$ the number of integers $0 \leq m \leq n$ such that there are precisely $c$ carries involved in adding $m$ to $n - m$ in base $b$. For $b = p$, Kummer's theorem renders this recurrence as a generalization of Fine's theorem, giving a way to compute the number $a_{p^\alpha}(n)$ of nonzero binomial coefficients modulo $p^\alpha$ in terms of the base-$p$ digits of $n$. For example, for $\alpha = 2$ we get the explicit expression

$$a_{p^2}(n) = \prod_{i=0}^{l}(n_i + 1) \cdot \left(1 + \sum_{i=0}^{l-1} \frac{p - (n_i + 1)}{n_i + 1} \cdot \frac{n_{i+1}}{n_{i+1} + 1}\right).$$

(Received September 18, 2009)

1056-11-973 **Shu Kawaguchi*** (kawaguch@math.sci.osaka-u.ac.jp), Department of Mathematics, Graduate School of Science, Osaka University, Toyonaka, Osaka 560-0043, Japan. *Local and global canonical height functions for affine space regular automorphisms.*

In this talk, I would first like to discuss local canonical height functions (i.e. Green functions) for affine space regular automorphisms defined over a non-archimedean valued field. Then I would like to consider regular automorphisms defined over a number field: If $f : \mathbb{A}^N \to \mathbb{A}^N$ is a regular automorphism defined over a number field $K$, then the sum of local canonical height functions over all places of $K$ gives rise to a global canonical height function, with which we can derive several arithmetic properties of f. If possible, I would like to talk some finiteness results about commuting regular automorphisms. (Received September 19, 2009)

1056-11-994 **Jing Long Hoelscher*** (jlong@math.arizona.edu), 617 N. Santa Rita Ave., P.O. Box 210089, Dept. of Math., University of Arizona, Tucson, AZ 85721. *Class numbers of function fields.* Preliminary report.

This talk will concern the divisibility of class numbers and their relation with Bernoulli numbers for function fields of positive characteristic. In number fields, the Herbrand-Ribet theorem gives a precise relation between the divisibility of class numbers and Bernoulli numbers. In function fields, the Herbrand's direction has been proven to be true, but the other direction has obvious conuter-examples. Gekeler reformulated a conjecture similar to Ribet's theorem. This talk will report some recent progress towards the Gekeler's conjecture. (Received September 19, 2009)

1056-11-1004 **Ralph Greenberg**, **Karl Rubin** and **Alice Silverberg***, Mathematics Department, University of California, Irvine, CA 92697-3875. *Mod 7 and 7-adic Galois representations of elliptic curves.*

Given a group $C$ of order 7 with a Galois action (in characteristic not 2, 3, or 7), we construct the family of all elliptic curves with a rational subgroup Galois-isomorphic to $C$. We study in detail the family where $C = \boldsymbol{\mu}_7^{\otimes 5}$, and give an application to images of 7-adic representations associated to elliptic curves over $\mathbb{Q}$. (Received September 19, 2009)

1056-11-1014 **Mihran Papikian*** (papikian@math.psu.edu), Department of Mathematics, Pennsylvania State University, University Park, PA 16802. *On generators of arithmetic groups over function fields.*

Let $K = \mathbb{F}_q(T)$ be the field of rational functions with $\mathbb{F}_q$-coefficients and $A = \mathbb{F}_q[T]$ be the subring of polynomials in $K$. Let $H$ be a division quaternion algebra over $K$ which is split at $1/T$. Given an $A$-order $\mathcal{H}$ in $H$, we determine an explicit set of generators of $\mathcal{H}^\times$. The proof uses Bruhat-Tits trees and modular curves of $\mathcal{D}$-elliptic sheaves. (Received September 19, 2009)

1056-11-1035 **Behailu Mammo*** (matbzm@hofstra.edu), 153 Lenox Ave, Uniondale, NY 11553. *On the density of discriminants of abelian extensions of a number field.*

For a number field $K$, let $N(K, G; m)$ denote the number of abelian extensions $L$ of $K$ with Galois group $G(L/K)$ isomorphic to $G = \mathbb{Z}/2\mathbb{Z} \times \mathbb{Z}/2\mathbb{Z}$ and the relative discriminant $D(L/K)$ of norm equal to $m$. The main object of this talk is to derive an explicit asymptotic formula for $\sum_{m \le X} N(K, \mathbb{Z}/2\mathbb{Z} \times \mathbb{Z}/2\mathbb{Z}; m)$. (Received September 20, 2009)

1056-11-1038 **Clifton Cunningham*** (cunning@math.ucalgary.ca), Department of Mathematics, University of Calgary, 2500 University Drive, Calgary, Alberta T2N 1N2, Canada. *On some local L-packets and character sheaves.*

There is a striking parallel between certain local L-packets of admissible representations and a partition of certain character sheaves into finite sets determined by the geometry of the underlying group. In this talk we present some examples of this parallel and examine to what extent it may be used to illuminate the structure of these local L-packets. (Received September 20, 2009)

1056-11-1047 **Jonathan Sondow*** (jsondow@alumni.princeton.edu), 209 West 97th Street Apt 6F, New York, NY 10025, and **Kieren MacMillan** (kieren@alumni.rice.edu), 49 Lessard Avenue, Toronto, Ontario M6S 1X6, Canada. *The Erdos-Moser equation $1^n + 2^n + \cdots + (m-1)^n = m^n$, related congruences, and primary pseudoperfect numbers.*

We give simple proofs of some old and new results towards the half-century-old conjecture that the only solution of the Diophantine equation in the title is $1 + 2 = 3$. We study related congruences and supercongruences, and connect them with primary pseudoperfect numbers. (Received September 20, 2009)

1056-11-1056 **David C. Torney*** (dtorney@valornet.com), 5 Sky High Way, Jemez Springs, NM 87025. *Prime Tuples.*

Consider $h$-tuples of prime integers with fixed increments: $(p, p + 2k_1, p + 2k_2, \ldots, p + 2k_{h-1})$; $2 \le h \in \mathbb{N}, k_1 < k_2 < \cdots < k_{h-1} \in \mathbb{N}$. These are *feasible* when having $> h$ instances. The infinitude of prime pairs has been an enduring open conjecture; proof of the infinitude for feasible prime $h$-tuples involves the following.

P. Kurlberg's Thm. 4, in *Intl. J. Num. Theory*, **5(3)**, 489-513 (2009) ensures polynomials $f \in \mathbb{Z}[x]$, $x \in \mathbb{Z}$ have range, modulo square-free $q \to \infty$, with null intersection with intervals of $L$ consecutive integers with asymptotic probability $\exp\{-\rho L\}$, $\rho$ denoting the density of the range. An $f$ is specified with respective range intersecting $[p_n + 1, p_n + 2 \ldots, p_n^2 - 2k_{h-1}]$; $n \in \mathbb{N} - 1$, only in integers which commence an $h$-tuple. The first entries of these $h$-tuples are non-congruent, $\mod p$, to any member of $\{0 \cup_{j=1}^{h-1} -2k_j \pmod p\}; p = p_2, p_3, \ldots, p_n$. $f$ derives from degree-$(p_i - 1)$ polynomials whose ranges are the respective, allowed congruences; $i = 2, 3, \ldots, n$. It is established that $[p_n + 1, p_n + 2, \ldots, p_n^2]$ must asymptotically contain an instance of the given prime $h$-tuple.
(Received September 20, 2009)

1056-11-1067 **W Duke*** (wdduke@ucla.edu), Dept of Math, UCLA, Los Angeles, CA 90024, and **O Imamoglu** and **A Toth**. *Real quadratic analogues of traces of singular moduli.*

Classical singular moduli are special values of the modular j-function at imaginary quadratic irrationalities and have well known importance for class field theory. I will describe some recent work with O. Imamoglu and A. Toth on certain real quadratic analogues of traces of singular moduli and their relation to mock modular forms.
(Received September 20, 2009)

1056-11-1082 **Paul Pollack*** (pppollac@illinois.edu). *Prime polynomials.*

While the study of the distribution of the prime numbers goes back over 2000 years, many unsolved problems remain. Two of the better-known examples are the twin prime conjecture on pairs $\{p, p+2\}$ and Goldbach's conjecture concerning representations of an even $N$ as a sum of two primes. In this talk we discuss what is known about problems of this type if one replaces the ring of rational integers by the ring of one-variable polynomials over a finite field. There are some surprises; for example (as first noticed by Chris Hall), one can establish a polynomial version of the twin prime conjecture from first principles in just a few pages. Some of the results we present constitute joint work with Andreas Bender of the Korea Institute for Advanced Study. (Received September 20, 2009)

1056-11-1083 **Guillermo Mantilla*** (mantilla@math.wisc.edu), Madison, WI 53705. *The growth of Mordell-Weil ranks on tower of Jacobians.* Preliminary report.

In this talk we describe a technique to bound the growth of Mordell-Weil ranks in towers of Jacobians of modular curves. In more detail, we will show the following result.

Let $p > 2$ be a prime, and let $J_n$ be the Jacobian of the principal modular curve $X(p^{n+1})$. Let $F$ be a number field with $\mu$-invariant $\mu$, and such that $J_0[p] \subseteq F$. We show that there exists a constant $C$, depending on $F$ and $p$, such that

$$\operatorname{rank} J_n(F) \leq \left(\frac{2p}{p^2-1}\right)[F:\mathbb{Q}] \dim J_n + C' p^{2n} + 2\mu n$$

for all $n$.
(Received September 20, 2009)

1056-11-1086 **Brooke Feigon*** (bfeigon@math.toronto.edu), Department of Mathematics, University of Toronto, Toronto, Ontario M5S2E4, Canada. *Periods and L-functions.*

In this talk, I will discuss some examples of relations between periods and $L$-functions. (Received September 20, 2009)

1056-11-1092 **Álvaro Lozano-Robledo*** (alozano@math.uconn.edu), Department of Mathematics, 196 Auditorium Road, University of Connecticut, U-3009, Storrs, CT 06269, and **Benjamin Lundell** (blundell@math.cornell.edu). *Bounds for the torsion subgroup of elliptic curves over fields with bounded ramification.*

Let $E$ be a semi-stable elliptic curve defined over $\mathbb{Q}$, and fix $N \geq 2$. Let $K/\mathbb{Q}$ be an algebraic Galois extension of $\mathbb{Q}$ whose ramification indices are all at most $N$. We show that there exists a computable bound $B(N)$, which depends only on $N$ and not on the choice of $E/\mathbb{Q}$ or $K$, such that the size of the torsion subgroup of $E(K)$ is always at most $B(N)$. The bound will be given explicitly during the talk, and some examples will be provided. This is joint work with Benjamin Lundell. (Received September 20, 2009)

1056-11-1109 **Amod Agashe*** (agashe@math.fsu.edu), Department of Mathematics, Florida State Univ, 208 Love Building, 1017 Academic Way, Tallahassee, FL 32306. *A formula for the special L-value of a modular abelian variety.*

We will describe a formula that expresses the the ratio of the special L-value to the real volume of a modular abelian variety as a lattice index of a certain group in another. The Birch and Swinnerton-Dyer conjecture expresses this ratio in terms of the orders of certain arithmetic groups associated to the abelian variety. We will discuss how our formula may be related to an equivariant version of the conjecture. (Received September 20, 2009)

1056-11-1110 **Michael W Daub*** (mwdaub@math.berkeley.edu), **Allison Pacelli**, **Michael Rosen**, **Jaclyn Lang**, **Mona Merling** and **Natee Pitiwan**. *Function Fields with Class Number Indivisible by a Prime $\ell$.*

It is known that infinitely many global function fields of any degree $m$ have class number divisible by a given integer $n$. However, significantly less is known about the indivisibility of class numbers of such fields. Pacelli and Rosen explicitly constructed an infinite class of global function fields of any degree with class number indivisible by 3, generalizing a result of Ichimura for quadratic extensions. We generalize their method to show that, for any prime $\ell$, there are infinitely many function fields of an arbitrary degree, subject to a few restrictions, with class number indivisible by $\ell$. (Received September 20, 2009)

1056-11-1111 **Jennifer Johnson-Leung*** (jenfns@uidaho.edu), Department of Mathematics, University of Idaho, PO Box 441103, Moscow, ID 83844-1103, and **Brooks Roberts**. *Siegel modular forms of degree two attached to Hilbert modular forms.*

Let $E/\mathbb{Q}$ be a real quadratic field and $\pi_0$ a cuspidal, irreducible, automorphic representation of $\mathrm{GL}(2, \mathbb{A}_E)$ with trivial central character and infinity type $(2, 2n+2)$ for some non-negative integer $n$. We show that there exists a Siegel paramodular newform $F : \mathfrak{H}_2 \to \mathbb{C}$ with weight, level, Hecke eigenvalues, epsilon factor and $L$-function determined explicitly by $\pi_0$. We tabulate these invariants in terms of those of $\pi_0$ for every prime $p$ of $\mathbb{Q}$. (Received September 20, 2009)

1056-11-1117 **Rafe Jones*** (rjones@holycross.edu), College of the Holy Cross, Worcester, MA 01610, and **Michelle Manes**, University of Hawaii-Manoa. *Discriminants and Galois groups for iterated rational functions.* Preliminary report.

Let $f$ be a rational function of degree two defined over a number field $K$. In this talk we consider the extensions $K_n$ obtained by adjoining the set $f^{-n}(0)$ to $K$, with a special interest in computing the Galois group of $K_n/K$. We show that the critical orbits of $f$ determine the discriminants of the $K_n$, and these in turn can sometimes be used to show $\mathrm{Gal}(K_n/K)$ is as large as possible. We pay particular attention to the special case where $f$ commutes with a non-trivial Mobius transformation. (Received September 21, 2009)

1056-11-1154 **Lance Edward Miller*** (lmiller@math.uconn.edu), 196 Auditorium Dr, Storrs, CT 06269. *On the Structure of Witt-Burnside rings over pro-p groups.*

The (classical) Witt vectors are a functorial construction which takes perfect fields of characteristic $p$ to $p$-adically complete domains of characteristic 0. In particular, finite fields of characteristic p go to rings of integers of finite unramified extensions of $\mathbf{Q}_p$. This functor was generalized by Dress and Siebeneicher to a functor $W_G$ associated to any profinite group $G$, with Witt's construction being the special case $G = \mathbf{Z}_p$. In this talk we will explore some examples of $W_G(k)$ where $G$ is a pro-$p$ group and $k$ is a field of characteristic p. In these examples we will see some properties that are surprising when compared to the classical case. (Received September 21, 2009)

1056-11-1161 **Douglas Ulmer*** (ulmer@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332. *Explicit points on elliptic curves over function fields.* Preliminary report.

I will discuss a simple construction of explicit points on elliptic curves with high rank over function fields and some arithmetic problems suggested by this construction. (Received September 21, 2009)

1056-11-1169 **Daniel P. Wisniewski*** (dwisniew@brynmawr.edu). *Tetranomial Thue Equations.* 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 problem of bounding the number of integer solutions $(p, q)$ of an arbitrary Thue equation, with $p$ and $q$ coprime. There has been a great deal of research on bounding this number for specific equations and on finding asymptotic bounds, as the degree goes to infinity, for the general question. In a 2000 paper, E. Thomas considered the special case of *trinomial* Thue equations, where $F$ has exactly three non-zero coefficients. Among other results, he gave an explicit numeric bound, independent of the degree and the values of the coefficients, on the number of integer solutions to arbitrary trinomial Thue equations of degree greater than or equal to 38.

In this talk, I will discuss recent work on the analogous problem with *tetranomial* Thue equations (where $F$ has exactly four non-zero coefficients). Working with a somewhat restricted set of tetranomial Thue equations, I will explain the methods I've used to obtain results similar to those of Thomas in the trinomial case. (Received September 21, 2009)

1056-11-1179 **Bo-Hae Im*** (imbh@cau.ac.kr), Dept. of Math., Chung-Ang University, 221 Heukseok-dong, Dongjak-gu, Seoul, 156-756, South Korea, and **Michael Larsen**, Indiana University, Bloomington. *Generalizing a Theorem of Richard Brauer.*

There exists a function $f\colon \mathbb{N} \to \mathbb{N}$ such that for every positive integer $d$, every quasi-finite field $K$ and every projective hypersurface $X$ of degree $d$ and dimension $\geq f(d)$, the set $X(K)$ is non-empty. This is a special case of a more general result about intersections of hypersurfaces of fixed degree in projective spaces of sufficiently high dimension over fields with finitely generated Galois groups. (Received September 21, 2009)

1056-11-1199 **Dibyajyoti Deb*** (ddeb@ms.uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40503. *Poincaré Series of Diagonal Polynomials.* Preliminary report.

Let $p$ be a prime number and $f(x_1,\ldots,x_n)$ be a polynomial with coefficients in $\mathbb{Z}$, the ring of integers. Let $c_m$ denote the number of solutions of $f \equiv 0 \pmod{p^m}$ with $c_0 = 1$. Then the *Poincaré Series* $P_f(y)$ is the generating function

$$P_f(y) = \sum_{i=0}^{\infty} c_i y^i.$$

Denef proved that $P_f(y)$ is always a rational function. We explicitly compute $P_f(y)$ when $f$ is an arbitrary diagonal polynomial, extending results of Qing Han. This is a special case of our main work that deals with diagonal polynomials over certain UFD's. We also present some new results that give a criterion for an element to be an $n^{th}$ power in a complete discrete valuation ring.

(Received September 21, 2009)

1056-11-1210 **Curtis N. Cooper*** (cooper@ucmo.edu), Dept. of Math. & Comp. Sci., University of Central Missouri, Warrensburg, MO 64093. *Two Identities Involving Generalized Fibonacci Numbers.*

Let $r \geq 2$ be an integer. The $r$-generalized Fibonacci sequence $\{G_n\}$ is defined as

$$G_n = \begin{cases} 0, & \text{for } 0 \leq n < r-1 \\ 1, & \text{for } n = r-1 \\ \sum_{i=1}^{r} G_{n-i}, & \text{for } n \geq r. \end{cases}$$

We will present two identities involving $r$-generalized Fibonacci numbers. (Received September 21, 2009)

1056-11-1219 **Kenneth A. Ribet*** (ribet@math.berkeley.edu), Mail Code 3840, 970 Evans Hall, Berkeley, CA 94720-3840. *Non-optimal levels of reducible two-dimensional mod $\ell$ representations of the Galois group of* $\mathbf{Q}$.

We are interested in the possible square free integers $N$ that are levels of classical weight-2 newforms with trivial character whose associated mod $\ell$ Galois representations are the direct sum of the trivial character and the mod $\ell$ cyclotomic character. B. Mazur determined all possible prime numbers $N$ that are such levels in 1977. We continue by treating the case where $N$ is the product of two distinct primes and obtaining partial information about the case where $N$ is an arbitrary product of distinct prime numbers.

This work will become part of a joint project with L. Dieulefait and J. Jiminez-Urroz. (Received September 21, 2009)

1056-11-1235 **Byungchan Kim** and **Jeremy Rouse***, 1409 W. Green Street, Urbana, IL 61801. *Explicit bounds for the number of $p$-core partitions of $n$.*

Let $p$ be a prime number. The generating function for the number of $p$-core partitions of $n$ is

$$\sum_{n=0}^{\infty} pc_p(n) q^n = \prod_{n=1}^{\infty} \frac{(1-q^{pn})^p}{1-q^n}.$$

We use the theory of modular forms, and the circle method of Hardy and Ramanujan to derive explicit bounds on $pc_p(n)$. (Received September 21, 2009)

1056-11-1237 **Hui June Zhu***, Department of Mathematics, SUNY at Buffalo, Buffalo, NY 14228.
*Reduction of crystalline representations and generalized Serre weights.*

We compute mod p reductions of 2-dimensional crystalline representations of $G_K$, where $K$ is a finite unramified extension of $\mathbf{Q}_p$, and hence generalize some results of Deligne, Fontaine-Serre, and Edixhoven to Galois representations arising from Hilbert modular forms. As applications, we prove one direction of a recent conjecture of Buzzard-Diamond-Jarvis on Serre weights. (Received September 21, 2009)

1056-11-1244 **C S Franze*** (craig.s.franze@gmail.com). *Sifting Limits for Selberg's $\Lambda^2\Lambda^-$ Sieve.* Preliminary report.

Selberg outlined the details of his $\Lambda^2\Lambda^-$ sieve in his collected papers. He asserted that for sufficiently large sieve dimensions $\kappa$, the sifting limit is $2\kappa + \frac{19}{36} + o(1)$. In contrast, the higher dimensional sieve developed by Diamond, Halberstam, and Richert has a sifting limit that is asymptotically $2.44\kappa$. While it is clear that Selberg's sieve is superior for sufficiently large $\kappa$, it is unknown as to how these sieves compare in small to moderately sized dimensions. To this end, I present some computations of the sifting limits for the $\Lambda^2\Lambda^-$ sieve. The computations suggest that the asymptotics for the sifting limits of the $\Lambda^2\Lambda^-$ sieve are achieved quite quickly.
(Received September 21, 2009)

1056-11-1297 **Gregory P. Dresden** and **Carrie E. Finch*** (finchc@wlu.edu), Mathematics Department, Washington & Lee University, Lexington, VA 24450, and **Josh Harrington**, **Lenny K. Jones** and **Mark R. Kozek**. *Special Sierpiński Numbers.* Preliminary report.

A Sierpiński number is an odd positive integer $k$ with the property that $k \cdot 2^n + 1$ is composite for all natural numbers $n$. In this talk, we present a survey of results concerning special Sierpiński numbers, such as Sierpiński numbers in the Fibonacci sequence (due to F. Luca and J. Mejía), consecutive Sierpiński numbers (due to Y.-G. Chen), and Sierpiński numbers that are also Riesel numbers (also due to Y.-G. Chen). We then present recent work concerning consecutive integers that are Sierpiński-like (joint work with G. Dresden and M. Kozek), and Sierpiński numbers of particular polynomial forms (joint work with L. Jones and J. Harrington). (Received September 21, 2009)

1056-11-1336 **Byungchan Kim*** (bkim4@illinois.edu), 1409 W. Green St, Urbana, IL 61801, and **Jeremy Rouse** (jarouse@math.uiuc.edu), 1409 W. Green St., Urbana, IL 61801. *D. Stanton's conjecture on t-core partitions.*

Let $t$ be a positive integer. The generating function for the number of $t$-core partitions of $n$ is

$$\sum_{n=0}^{\infty} a_t(n)q^n = \prod_{n=1}^{\infty} \frac{(1-q^{tn})^t}{1-q^n}.$$

Stanton conjectured that for all $t \geq 4$,

$$a_{t+1}(n) \geq a_t(n),$$

for all $n \geq t+1$. In this talk, by using an explicit upper bound for the number of $t$-core partitions, we show Stanton's conjecture is true for small $t$'s. (Received September 21, 2009)

1056-11-1363 **Riad Masri*** (masri@math.wisc.edu), University of Wisconsin, Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706, and **Tonghai Yang**. *Nonvanishing of canonical Hecke L-functions for CM number fields.*

In the early 1980's, Rohrlich defined a class of "canonical" Hecke characters of CM number fields. These characters are associated to CM abelian varieties with some nice arithmetic properties. In this talk, I will discuss some results on the nonvanishing of canonical Hecke L-functions and their application to ranks of abelian varieties. This is joint work with Tonghai Yang. (Received September 21, 2009)

1056-11-1383 **Thomas J Wright*** (wright@math.jhu.edu), Johns Hopkins University, Department of Mathematics, 3400 North Charles St., Baltimore, MD 21218. *Diophantine Questions and the Adeles.*

In this talk, we discuss new developments in adelic methods for Diophantine problems. In particular, we show how they can be used to approximate the number of solutions to Diophantine equations, as well as how they might be used to shed light on questions such as the Goldbach Conjecture or Twin Prime Conjecture. (Received September 21, 2009)

1056-11-1400 **Tom Osler** (osler@rowan.edu), 201 Mullica Hill Road, Glassboro, NJ 08028, and **Abdul Hassen*** (hassen@rowan.edu), 201 Mullica Hill Rd, Glassboro, NJ 08080. *On Generalization of Lambert Series.*

The classical Lamberts series makes it possible to generate many remarkable transformations of series. These Lamberts series are all constructed from the function $z/(1-z)$. In this paper we show how to generalize these series by using an arbitrary function in place of $z/(1-z)$. Series transformations exhibiting beautiful symmetry are obtained. In addition, a double contour integral is found which represents these series. Our method is compared to a general procedure introduced by MacMahon. (Received September 21, 2009)

1056-11-1403 **Daniel W Bump***, Department of Mathematics, Building 380, Stanford, CA 94305-2125. *Schur polynomials, metaplectic Whittaker functions and the Yang-Baxter equation, by Daniel Bump, Ben Brubaker and Solomon Friedberg.*

It was shown by Hamel and King that a Schur polynomial times a deformation of the Weyl denominator could be expressed as the partition function of a statistical mechanical system, the six vertex model with particular Boltzmann weights. A new proof of this is given using the Yang-Baxter equation. Using the Casselman-Shalika formula, this gives an interpretation of the Whittaker function on GL(n,F) where F is a p-adic field. This "statistical" interpretation extends to the metaplectic covers of GL(n,F), and gives a new method of studying p-adic Whittaker functions. (Received September 21, 2009)

1056-11-1463 **Ben Brubaker***, 2-267 MIT, 77 Massachusetts Ave., Cambridge, MA 02139, and **Catherine Lennon**. *Lennon's work on relations between traces of Frobenius and hypergeometric functions.* Preliminary report.

I will report on my graduate student Cathy Lennon's results describing the trace of Frobenius for various families of elliptic curves in terms of Greene's finite field hypergeometric functions. The story involves three flavors of hypergeometric functions – classical Gaussian hypergeometric functions, their truncated series, and the finite field type described above which have Jacobi sums replacing the usual binomial coefficients. I'll explain the rather surprising way in which these series are related, offer a few unexplained mysteries, and discuss why the finite field type may really be the best for expressing the trace of Frobenius. If time permits, we'll discuss a few of the applications that result from these identities. (Received September 21, 2009)

1056-11-1527 **Mitsuo Kobayashi*** (mitskobay@dartmouth.edu), 6188 Kemeny Hall, Hanover, NH 03755. *On the Density of Abundant Numbers.* Preliminary report.

A natural number is called abundant if it is smaller than the sum of its proper divisors. It is known that the abundant numbers have a positive asymptotic density which has been calculated by Deléglise to be $0.247\ldots$. We will present results on the computational complexity of the algorithm used by Deléglise as well as recent improvements to the algorithm which allow us to discover the next decimal digit. (Received September 22, 2009)

1056-11-1529 **Ekin Ozman*** (ozman@math.wisc.edu). *Points on Quadratic Twists of $X_0(N)$.*

Let $X^d(N)$ be the modular curve described as qudratic twist of $X_0(N)$ by a quadratic field $K=\mathbb{Q}(\sqrt{d})$ and $w_N$. Rational points on this twist are $K$-rational points of $X_0(N)$ that are fixed by $\sigma$ composed with $w_N$ where $\sigma$ is the generator of $Gal(K/\mathbb{Q})$. Unlike $X_0(N)$, it's not immediate to say that there are points (global or local) on $X^d(N)$. Given $(N,d,p)$ we give necessary and sufficient conditions for existence of a $\mathbb{Q}_p$-rational point on $X^d(N)$, answering the following question of Ellenberg:

For which $d$ and $N$ there exists points on $X^d(N)$ for every completion of $\mathbb{Q}$? (Received September 22, 2009)

1056-11-1554 **Jennifer Paulhus*** (paulhus@math.ksu.edu), Department of Mathematics, 138 Cardwell Hall, Kansas State University, Manhattan, KS 66506, and **Todd Cochrane** and **Christopher Pinner**. *On the parity of k-th powers mod p.*

Given a prime $p$, Lehmer asked for the number $N_{-1}$ of even residues in $\mathbb{Z}/p$ whose inverse is odd modulo $p$. Zhang proved that $N_{-1}\sim p/4$. We consider a more general problem: given $k$, $A$ any integers with $p$ not dividing $A$, determine the number $N_k$ of even residues such that $Ax^k$ is odd modulo $p$. In this more general case, $N_k$ is not always asymptotic to $p/4$. We briefly discuss the use of exponential sum methods to prove many cases where $N_k\sim p/4$ as well as highlight a few examples where bias occurs. (Received September 22, 2009)

1056-11-1556 **Kyu-Hwan Lee** (khlee@math.uconn.edu) and **Philip J Lombardo*** (lombardo@math.uconn.edu), 814 Mansfield City Rd. Apt. 12B, Storrs-Mansfield, CT 06268. *The Constant Terms of Eisenstein Series on Loop Groups over a Function Field.*

In 2001, Howard Garland published a paper in which he constructed Eisenstein series on arithmetic quotients of loop groups over the real field. He obtained a formula for the constant terms of these series, and showed the existence of a meromorphic continuation and functional equations of the constant term. In this talk, we generalize his work by defining Eisenstein series on loop groups over a function field, and computing a formula for the constant term. (Received September 22, 2009)

1056-11-1557 **Michael Patrick Dewar*** (mdewar2@math.uiuc.edu), University of Illinois at Urbana-Champaign, Department of Mathematics, 1409 West Green Street, Urbana, IL 61801. *Ramanujan-type congruences in partition-theoretic counting functions.*

Ramanujan famously proved congruences modulo 5, 7, and 11 for the partition function (for example, he showed that $p(5n+4) = 0 \mod 5$). He speculated that there were no other such congruences, and in 2003 Ahlgren and Boylan proved that this was indeed the case. We describe results in this direction for other classes of combinatorial functions which can be described using modular forms. Moreover, we place these results in context by providing the exact probability that a modular form has this type of congruence. (Received September 22, 2009)

1056-11-1569 **Ben J Green*** (b.j.green@dpmms.cam.ac.uk), Centre for Mathematical Sciences, Wilberforce Road, Cambridge, CB3 0WA, England. *Approximate groups and their applications: work of Bourgain, Gamburd, Helfgott and Sarnak.*

This is a survey of several exciting recent results in which techniques originating in the area known as additive combinatorics have been applied to give results in other areas, such as group theory, number theory and theoretical computer science.

We begin with a discussion of the notion of an approximate group and also that of an approximate ring, describing key results of Freiman-Ruzsa, Bourgain-Katz-Tao, Helfgott and others in which the structure of such objects is elucidated.

We then move on to the applications. In particular we will look at the work of Bourgain and Gamburd on expansion properties of Cayley graphs on $\mathrm{SL}_2(\mathbb{F}_p)$ and the existence of a spectral gap for certain sets of generators in SU(2), and at the work of Bourgain, Gamburd and Sarnak on nonlinear sieving problems.

This being a survey, all of the notions mentioned here will be introduced from scratch. Technical details will be kept to an absolute minimum. (Received September 22, 2009)

1056-11-1609 **Soundararajan Kannan*** (ksound@stanford.edu), Department of Mathematics, Stanford University, Stanford, CA 94305. *Recent progress on QUE.*

I will discuss some recent results on the Quantum Unique Ergodicity conjecture of Rudnick and Sarnak. (Received September 22, 2009)

1056-11-1633 **Kristin E. Lauter*** (klauter@microsoft.com), Microsoft Research, One Microsoft Way, Redmond, WA 98052, and **Bianca Viray**, **Jennifer Johnson-Leung**, **Adriana Salerno**, **Erika Frugoni** and **Helen Grundman**. *Numerical evidence for Bruinier-Yang conjecture and comparison with denominators of Igusa class polynomials.*

Bruinier and Yang conjectured a formula for an intersection number on the arithmetic Hilbert modular surface, $\mathrm{CM}(K).T_m$, where $\mathrm{CM}(K)$ is the zero-cycle of points corresponding to abelian surfaces with CM by a primitive quartic CM field $K$, and $T_m$ is the Hirzebruch-Zagier divisors parameterizing products of elliptic curves with an m-isogeny between them. In this talk, we examine fields not covered by Yang's proof of the conjecture. We give numerical evidence to support the conjecture and point to some interesting anamolies. We compare the conjecture to both the denominators of Igusa class polynomials and the number of solutions to the embedding problem stated by Goren and Lauter. (Received September 22, 2009)

1056-11-1637 **Xuemei Ye***, yexuemei@msu.edu, and **Aklilu Zeleke**. *Some Remarks on Diophantine Triples.* Preliminary report.

Let a, b, c be positive integers. We say the triple $(a, b, c)$ is a Diophantine triple if $ab + 1$, $bc + 1$ and $ac + 1$ are all perfect squares. In this talk we discuss algorithms and recurrence relations that can be used to generate infinite sequences of Diophantine triples. Some generalizations to the case when $ab + d$, $ac + d$ and $bc + d$, for $d > 1$ will also be presented. (Received September 22, 2009)

1056-11-1669 **Kristin E. Lauter*** (klauter@microsoft.com), Microsoft Research, One Microsoft Way, Redmond, WA 98052, and **Eyal Z. Goren**. *A Gross-Zagier formula for quaternion algebras over totally real fields.* Preliminary report.

The values of the elliptic modular j-function at imaginary quadratic numbers are called singular moduli. They generate the Hilbert class field of the imaginary quadratic field and are of fundamental importance in the study of elliptic curves and in algebraic number theory, including the study of elliptic curves over finite fields. The formula of Gross and Zagier for the factorization of the norm of differences of singular moduli can be viewed as a solution to the problem of counting simultaneous embeddings of the rings of integers of two imaginary quadratic fields into a maximal order in the quaternion algebra ramified only at p and infinity. In this talk I will describe results generalizing Gross and Zagier's formula to counting simultaneous embeddings of the rings of integers of two primitive quartic CM fields into certain orders in a quaternion algebra over a totally real field. This result has applications to the problem of constructing genus 2 curves for use in cryptography. (Received September 22, 2009)

1056-11-1735 **Leanne Robertson*** (robertle@seattleu.edu), Mathematics Department, Seattle University, 901 12th Ave., Seattle, WA 98122. *Monogenity in cyclotomic fields.*

A number field is said to be *monogenic* if its ring of integers is a simple ring extension $\mathbf{Z}[\alpha]$ of $\mathbf{Z}$. It is a classical and usually difficult problem to determine whether a given number field is monogenic, and if it is, to find all numbers $\alpha$ that generate a power integral basis $\{1, \alpha, \alpha^2, \ldots, \alpha^k\}$ for the ring. We consider cyclotomic fields, which are known to be monogenic, and by studying units in the ring arrive at a conjectural solution to the problem of finding all the power integral bases for these fields. G. Ranieri recently proved that if $L = \mathbf{Q}(\zeta_n)$ is a cyclotomic field whose conductor $n$ is relatively prime to 6, then up to integer translation all the generators lie on the unit circle or the line $\mathrm{Re}(z) = 1/2$ in the complex plane. We prove that this interesting geometric restriction extends to the cases of conductor $n = 3k$ and $n = 4k$, where $k$ is relatively prime to 6. We use this result to find all power integral bases for $\mathbf{Q}(\zeta_n)$ for $n = 15, 20, 21, 28$, and so verify our conjecture in these cases. (Received September 22, 2009)

1056-11-1738 **John R. Greene*** (jgreene@d.umn.edu), University of Minnesota Duluth, Department of Mathematics and Statistics, 1117 University Drive, Duluth, MN 55812, and **Melissa Larson**. *An elementary approach to proving and discovering BBP-type formulas.*

We consider formulas of the form

$$\sum_{k=0}^{\infty} x^{nk}\left(\frac{a_1}{nk+1} + \frac{a_2}{nk+2} + \cdots + \frac{a_n}{nk+n}\right) = \alpha,$$

which are a special case of what are refered to as BBP-type formulas. We show that all such formulas can be verified by evaluating appropriate definite integrals of rational functions. We give some infinite classes of formulas of this type and discuss how to combine them so as to obtain "nice" formulas for $\pi$. (Received September 22, 2009)

1056-11-1751 **Arthur Baragar*** (baragar@unlv.nevada.edu), University of Nevada Las Vegas, 4505 Maryland Parkway, Las Vegas, NV 89154-4020. *Some fractals associated to $K3$ surfaces.*

In this talk, we look at the fractal nature of the boundary at infinity of the ample cone for some $K3$ surfaces, and relate it to the asymptotic growth of rational points under the action of the surface's group of automorphisms. (Received September 22, 2009)

1056-11-1794 **Jang-Woo Park*** (jpark@clemson.edu), Department of Mathematical Sciences, O-3 Martin Hall, Clemson University, Clemson, SC 29634-0975, and **Shuhong Gao** (sgao@clemson.edu), Department of Mathematical Sciences, O-301 Martin Hall, Clemson University, Clemson, SC 29634-0975. *Dynamics of f(x) = x+1/x via Elliptic Curves.*

Understanding dynamics of nonlinear maps is an important but difficult, and there are not many methods available. In this talk, we study the dynamics of a simple function, f(x) = x + 1/x, on fields of characteristic two. The main idea is to lift the dynamics of an isogeny on an elliptic curve and study the dynamics of the isogeny on the curve. (Received September 22, 2009)

1056-11-1819 **Paul R Bialek*** (pbialek@tiu.edu), Department of Mathematics, Trinity International University, 2065 Half Day Rd, Deerfield, IL 60015, and **Dominic W Klyve**. *Euler's work on the prime divisors of numbers of the form $mx^2 + ny^2$.*

It is well known that if a positive integer $n$ can be expressed as the sum of two squares $x^2 + y^2$, then in the prime factorization of $n$ no prime congruent to 3 modulo 4 has an odd exponent. In his paper, "On divisors of numbers contained in the form mxx + nyy" [E744], Euler considers the more general question of which numbers can be expressed in the form $mx^2 + ny^2$. More precisely, he determines what congruence classes modulo $4mn$ the divisors must belong to, and presents several examples. We will present a translation from the Latin and summary of this previously untranslated paper. (Received September 22, 2009)

1056-11-1864 **Dominic Lanphier*** (dominic.lanphier@wku.edu), Department of Mathematics, Western Kentucky University, 1906 College Heights Blvd #11078, Bowling Green, KY 42101-1078. *Values of Asai L-functions and combinatorial identities.* Preliminary report.

We study an integral representation of the Asai L-function. This integral, originally due to Ghate, can be used to obtain certain special value results of the L-function. Ghate made an explicit conjecture concerning the gamma factors of this integral, and we investigate this conjecture. As a consequence we obtain some interesting combinatorial identities. (Received September 22, 2009)

1056-11-1871 **Timothy Lee Gillespie*** (tim-gillespie@uiowa.edu), 727 East Michael St. Apt 84, Iowa City, IA 52246. *Cyclic Base change and Rankin-Selberg Convolutions.*

Let $\pi$ be an automorphic cuspidal representation of $GL_n(\mathbb{A}_E)$ with unitary central character where $E$ is a cyclic extension of prime degree $\ell$, and $\pi$ is invariant under the action of $Gal(E/\mathbb{Q})$. Similarly, let $\pi'$ be an automorphic cuspidal representation of $GL_m(\mathbb{A}_F)$ where $F$ is also cyclic of prime degree $\ell$ and $\pi'$ is invariant under the action of $Gal(F/\mathbb{Q})$. Using a result of Arthur and Clozel we define a Rankin-Selberg L-function attached to $\pi$ and $\pi'$ an prove a prime number theorem for this L-function. (Received September 22, 2009)

1056-11-1900 **Mark Kozek*** (mkozek@whittier.edu), Mathematics Department, Whittier College, Whittier, CA 90608-0634. *An asymptotic formula for Goldbach's conjecture with monic polynomials.*

Let $f(x)$ be a monic polynomial in $\mathbb{Z}[x]$ of degree $d > 1$. Hayes (1965) proved a form of Goldbach's conjecture with monic polynomials: there exist irreducible monic polynomials $g(x)$ and $h(x)$ in $\mathbb{Z}[x]$ with the property that $f(x) = g(x) + h(x)$. We give a proof that the number $\mathfrak{R}(y)$ of representations of $f(x)$ as a sum of two irreducible monic polynomials $g(x)$ and $h(x)$ in $\mathbb{Z}[x]$, with the coefficients of $g(x)$ and $h(x)$ bounded in absolute value by $y$, is asymptotic to $(2y)^{d-1}$. (Received September 22, 2009)

1056-11-1906 **Thai Hoang Le*** (leth@math.ucla.edu), UCLA Mathematics Department, Box 951555, Los Angeles, CA 90095-1555. *Green-Tao theorem in function fields.*

We adapt the proof of the Green-Tao theorem on arithmetic progressions in primes to the setting of polynomials over a finite field, to show that for every $k$, the irreducible polynomials in $\mathbf{F}_q[t]$ contain configurations of the form $\{f + Pg : (P) < k\}, g \neq 0$. (Received September 22, 2009)

1056-11-1936 **Nahid Walji*** (nahid@caltech.edu). *Supersingular distribution on average for congruence classes of primes.*

A general question of interest is to know, for elliptic curves over a number field, the distribution of supersingular primes of degree one. We begin by modifying the Lang-Trotter heuristic to address the case of an abelian extension, then we show that it holds on average (up to a constant) for a family of elliptic curves by using ideas of David-Pappalardi. (Received September 22, 2009)

1056-11-2118 **Ciarán Mac an Bhaird*** (ciaranmacanbhaird@gmail.com), Department of Mathematics, National University of Ireland Maynooth, Maynooth, Co Kildare, Ireland, and **Pat McCarthy**. *Gauss' Method for determining cyclotomic numbers.*

It is commonly believed that Gauss' method for the determination of Cyclotomic Numbers, and thus the determination of the minimal polynomial of Gaussian Periods, is unwieldy for the general case.

We have shown that Gauss' method leads to a series of functional equations. We have necessary and sufficient conditions for these equations to have integer solutions. This leads to a purely Diophantine system of equations, the number of equations is independent of the prime $p$, where $p$ is congruent to 1 modulo $l$. The system has precisely $\phi(l)$ solutions, which correspond to the cyclotomic numbers of order $l$.

This is, in fact, the first purely Diophantine characterisation of the cyclotomic numbers and the coefficients of the minimal polynomial of the Gaussian periods and the problem is solved for all orders. Using this method, we will go through the cyclotomic numbers of order 3, 5 and 7 and discuss some interesting aspects of these and further orders. (Received September 23, 2009)

1056-11-2153 **Maria Monks***, Department of Mathematics, M.I.T., Cambridge, MA. *Modular forms arising from Q(n) and Dyson's rank.*

Let $R(w;q)$ be Dyson's generating function for partition ranks. For roots of unity $\zeta \neq 1$, it is known that $R(\zeta;q)$ and $R(\zeta;1/q)$ are given by harmonic Maass forms, Eichler integrals, and modular units. We show that modular forms arise from $G(w;q)$, the generating function for ranks of partitions into distinct parts, in a similar way. If $D(w;q) := (1+w)G(w;q)+(1-w)G(-w;q)$, then for roots of unity $\zeta \neq \pm 1$ we show that $q^{\frac{1}{12}} \cdot D(\zeta;q)D(\zeta^{-1};q)$ is a weight 1 modular form. Although $G(\zeta;1/q)$ is not well defined, we show that it gives rise to natural sequences of $q$-series whose limits involve infinite products (and modular forms when $\zeta = 1$). (Received September 29, 2009)

# 12 ► *Field theory and polynomials*

1056-12-257 **Steven H. Weintraub*** (shw2@lehigh.edu), Dept. of Mathematics, Lehigh Univ., Bethlehem, PA 18015-3174. *Observations on Primitive, Normal, and Subnormal Elements of Field Extensions.*

Let $\mathbf{B}_1$ and $\mathbf{B}_2$ be disjoint separable algebraic extensions of a field $\mathbf{F}$, and let $\mathbf{B} = \mathbf{B}_1\mathbf{B}_2$ be their composite. Let $\alpha_1$ be an element of $\mathbf{B}_1$ and $\alpha_2$ be an element of $\mathbf{B}_2$. Suppose $\alpha_1$ and $\alpha_2$ are primitive (resp. normal, resp. subnormal). We investigate the question of when $\alpha_1 + \alpha_2$ and $\alpha_1\alpha_2$ are necessarily primitive (resp. normal, resp. subnormal) elements of $\mathbf{B}$. (A normal element of a Galois extension is defined to be one that is part of a normal basis, and a subnormal element is defined analogously for a non-Galois extension.) (Received August 25, 2009)

1056-12-271 **Brian C Irick*** (irick@math.utk.edu), Department of Mathematics, 104 Aconda Court, 1534 Cumberland Avenue, Knoxville, TN 37996-0612. *On the Irreducibility of Cauchy-Mirimanoff Polynomials.* Preliminary report.

The Cauchy-Mirimanoff Polynomials are a class of polynomials that naturally arise in various classical studies of Fermat's Last Theorem. Originally conjectured to be irreducible over 100 years ago, the irreducibility of the Cauchy-Mirimanoff polynomials is still an open conjecture. Some new results will be presented. (Received August 24, 2009)

1056-12-429 **V Ravi Srinivasan*** (ravisri@rutgers.edu), 101 Warren Street, Smith Hall 207, Newark, NJ 07102. *Iterated Antiderivative Extensions.* Preliminary report.

Let $F$ be a differential field with an algebraically closed field of constants and let $E$ be a differential field extension of $F$ with no new constants. We say that $E$ is an *Iterated Antiderivative Extension* of $F$, abbreviated *IAE*, if there is a tower of differential fields $F = F_0 \subset F_1 \subset \cdots \subset F_n = E$ such that for each $i = 1, 2, \cdots, n$, $F_i = F_{i-1}(\mathbf{x}_i)$ and $\mathbf{x}_i \in E$ is an antiderivative of $F_{i-1}$. In this talk, we will show that if $E$ is an *IAE* of $F$ and $K$ is a differential subfield of $E$ such that $K \supseteq F$ then $K$ is an *IAE* of $F$ as well. (Received September 06, 2009)

1056-12-493 **Crystal Lee Clough*** (clclough@ntu.edu.sg). *Square Encryption Schemes: New Directions in Multivariate Public-Key Cryptography.*

We describe and analyze a new family of multivariate public-key encryption schemes, characterized by large characteristic and low degree core maps. (Received September 10, 2009)

1056-12-605 **Phyllis J Cassidy** (pcassidy@ccny.cuny.edu), Department of Mathematics, The City College of New York, New York, NY 10038, and **Michael F Singer*** (singer@math.ncsu.edu), Department of Mathematics, Box 8205, North Carolina State University, Raleigh, NC 27695-8205. *Differential Groups and Factorization of Partial Differential Operators.*

It is well known that an ordinary differential operator factors as a product of irreducible operators and that in any such factorization the number of such factors is unique. This uniqueness no longer holds for partial differential operators. We show that a Jordan-Hoelder type theorem for differential groups gives a kind of factorization into irreducibles where in any such factorization the number of "factors" are unique and, after a possible permutation are equivalent in a suitable sense. (Received September 15, 2009)

1056-12-688 **Ha N Nguyen*** (hnnguye@emory.edu), 1506 Tuxworth Cir, Decatur, GA 30033, and **Victoria Powers** (vicki@mathcs.emory.edu), 400 Dowman Dr., W401, Atlanta, GA 30322. *Representations of polynomials non-negative on non-compact subsets of* $\mathbb{R}^2$.

Recently, M. Marshall settled a long-standing question in real algebraic geometry by showing that if $f(x,y) \in \mathbb{R}[x,y]$ and $f(x,y) \geq 0$ 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 the background to this result, which goes back to Hilbert's 17th problem, and our generalizations to other non-compact subsets of $\mathbb{R}^2$. (Received September 15, 2009)

1056-12-841 **Thomas Scanlon*** (scanlon@math.berkeley.edu), University of California, Berkeley, Department of Mathematics, Evans Hall, Berkeley, CA 94720-3840. *Dynamical Mordell-Lang results via Euclidean uniformizations.*

I will explain the simple observation that for some dynamical systems admitting real analytic uniformizations around attracting fixed points one may deduce a positive solution to the dynamical Mordell-Lang problem. (Received September 17, 2009)

1056-12-850 **Andrew C Schultz*** (andrew.c.schultz@gmail.com), 1409 W Green St, Urbana, IL 61801. *Forcing the appearance of Galois groups: new automatic realization results for p-groups.*

One of the outstanding problems in Galois theory is to determine conditions on a group $G$ and field $F$ that explicitly determine whether $G$ appears as the Galois group of some extension $E/F$. One can also ask relative versions of this same question, such as whether the appearance of one group $G_1$ as a Galois group over $F$ forces the appearance of another group $G_2$ as a Galois group over $F$. In such a case, we say that $G_1$ automatically realizes $G_2$. In this talk we'll give some new automatic realization results when $G_1$ and $G_2$ are extensions of $\mathbb{Z}/p^n\mathbb{Z}$ by elementary $p$-abelian groups. One can also ask for the minimum number of times a group $G$ can appear as a Galois group over $F$, provided that it appears at least once; this is the so-called realization multiplicity of $F$. In this talk we'll also discuss some new results which describe several groups with large realization multiplicity. (Received September 18, 2009)

1056-12-942 **Daniel C. Smith*** (smithdc@indiana.edu), Indiana University, Department of Mathematics, 831 East 3rd St, Bloomington, IN 47405. *The Effect of Projection on the Symmetry of the SFLASH Attack.*

Dubois, Fouque, Shamir, and Stern published an attack in 2007 which breaks SFLASH and many other multivariate public key schemes similar to $C^{*-}$. The attack relies on a multiplicative symmetry exhibited by the hidden internal field map of the encryption function. Ding later suggested projection, the method previously called "fixing," as a means of preventing the attack. We present a detailed analysis of the effect of projection on the multiplicative symmetry including a proof of Ding's suggestion as well as the discovery of a new symmetry preserved under projection. (Received September 18, 2009)

1056-12-1040 **Arne Ledet*** (arne.ledet@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042, and **Lourdes Juan**, Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX. *Spin groups as differential Galois groups.*

We present some recent results about the realisation of spin groups as differential Galois groups, using quadratic forms theory to describe the cohomology. (Received September 20, 2009)

1056-12-1496 **Gregory V. Bard*** (bard@fordham.edu), Department of Mathematics, John Mulcahey Hall, Fordham University, Bronx, NY 10530. *Algebraic Attacks on Bivium and Trivium, Accelerated by Cutting the Variable-Sharing Graph.*

The stream ciphers Bivium and Trivium appear very simple, and intuition says that they should be therefore easily breakable. While Bivium has been the subject of many published attacks, Trivium remains notoriously difficult.

In their 2008 paper, Kenneth Wong, Gregory Bard and Robert Lewis introduced the variable-sharing graph, and showed how balanced vertex-cuts of this graph can accelerate algebraic attacks, by a wide margin.

The variable-sharing graph has a vertex for each variable in a polynomial system of equations. There is an edge between two variables if and only if those two variables ever appear together in the same equation. By searching for balanced vertex-cuts one can break the polynomial system into two smaller ones.

In that paper, such a cut was used to simulate an attack under the assumption that a few bits of the key have been leaked. A polynomial system of equations is constructed, and a balanced vertex-cut is found, which results in two easily solved systems. While other types of polynomial systems were discussed in the paper (e.g. game theory, computational geometry, molecular chemistry), Bard will focus on the Bivium and Trivium attacks for this talk. (Received September 22, 2009)

1056-12-1534 **Jennifer S Berg*** (jensberg@gmail.com), 509 W. Main St., Apt. 3, Urbana, IL 60613. *Galois groups via Galois modules in Artin-Schreier theory.* Preliminary report.

The inverse Galois problem is still one of the greatest open problems in group theory. It asks, given a group G and a field F, can we always find a Galois extension of F having Galois group G? Kummer theory answers this question for fields F containing primitive pth-roots of unity and groups G that are direct sums of Z/pZ's.

In such cases, adjoining pth-roots of elements to F yields finite Galois extensions with abelian Galois groups of exponent p, and conversely every such Galois extension is of this form. Furthermore, if we are given that F is a finite Galois extension over some field B, and L is a Kummer extension of F, it is straightforward to determine whether L is also Galois over B. In that case, it is possible to characterize the Galois group of L over B by computations within F. The goal of my research is to extend this result to Artin Schreier theory, the positive characteristic analogue to Kummer theory. (Received September 22, 2009)

1056-12-1621 **Ding Jintai*** (ding@math.uc.edu), Dept. Math. Sci., ML 0025, Cincinati, OH 45242. *Solving multivariate polynomial equations over finite fields.* Preliminary report.

Solving multivariate polynomials over finite fields becomes increasingly important in many areas including cryptography. In this talk, we will present some of the new progresses in the area of polynomial solving in the last few years and some of the critical challenges in terms of its applications in cryptography. (Received September 22, 2009)

1056-12-2077 **Jason Worth Martin*** (martinjw@jmu.edu), MSC 1911 (305 Roop Hall), Harrisonburg, VA 22807. *Parallel Performance of Some SHA-3 Second Round Candidates.* Preliminary report.

The National Institute of Standards and Technology is currently holding the second round of a competition to select SHA-3, the next federal hashing standard. Fourteen candidate algorithms remain in the contest, and in this presentation we consider the parallel performance of several of the algorithms. We use two common parallel architectures: multi-core CPUs and video cards. Current video cards from NVIDIA have hundreds of processing cores which can be readily harnessed for data-parallel computations such as tree hashing. To create a fair comparison of the algorithms we place their compression functions inside of a single tree-based structure and investigate their performance on mid-range video cards and large multi-core systems when hashing extremely large messages. (Received September 23, 2009)

# 13 ► Commutative rings and algebras

1056-13-6 **Olga Holtz*** (holtz@math.ias.edu), Institute for Advanced Study, School of Mathematics, Einstein Drive, Princeton, NJ 08540, and **Amos Ron** (amos@cs.wisc.edu), Department of Computer Sciences, University of Wisconsin-Madison, 1210 West Dayton street, Madison, 53706. *Zonotopal algebra, analysis and combinatorics.*

A great number of geometric and combinatorial properties of a given linear endomorphism $X$ of $R^N$ is captured in the study of its associated zonotope $Z(X)$, and, by duality, its associated hyperplane arrangement $H(X)$. Of particular interest in various applications is the case $n \ll N$. We perform this study at an algebraic level, and associate $X$ with three algebraic structures, referred as *external, central, and internal.* Each algebraic structure is given in terms of a pair of homogeneous polynomial ideals in $n$ variables that are dual to each other: one encodes properties of the arrangement $H(X)$, while the other encodes by duality properties of the zonotope $Z(X)$. The algebraic structures are defined purely in terms of the combinatorial structure of $X$, but are subsequently proved to be equally obtainable by applying suitable algebraic or analytic operations to either of $Z(X)$ or $H(X)$. The theory is universal in the sense that it requires no assumptions on the map $X$, and provides new tools that can be used in enumerative combinatorics, graph theory, representation theory, polytope geometry, and analysis. (Received September 22, 2009)

1056-13-98 **Anne Shiu*** (annejls@math.berkeley.edu) and **Bernd Sturmfels**. *Siphons in biochemical reaction systems: an algebraist's point of view.*

Siphons in a biochemical reaction system are subsets of the species that have the potential of being absent in a steady state. We characterize minimal siphons in terms of primary decomposition of binomial ideals, explore the underlying geometry, and demonstrate the computation of siphons using computer algebra software. This leads to a new method for determining whether given initial concentrations allow for various boundary steady states. (Received July 26, 2009)

1056-13-179 **R. Karpman*** (rkarpman@scrippscollege.edu), Scripps College, Box 591, Claremont, CA 91711, and **N. Arnosti**, **C. Leverson**, **J. Levinson** and **S. Loepp**. *Excellent Local Rings with Semi-Local Formal Fibers.*

We begin by defining a metric on a polynomial ring. With respect to this metric, not all Cauchy sequences converge. When we complete the polynomial ring, we obtain a power series ring. The idea of completing a polynomial ring generalizes to any local ring. In this talk, we will present an original result relating the minimal prime ideals of a local ring to the prime ideals of its completion. In particular, we consider a complete local (Noetherian) ring $T$ containing the rationals, and a finite set $\mathcal{C}$ of prime ideals of $T$. Let $\mathcal{C}_1, \ldots, \mathcal{C}_m$ partition $\mathcal{C}$ into $m$ subsets. We find necessary and sufficient conditions for $T$ to be the completion of an excellent reduced local ring $A$ with precisely $m$ minimal prime ideals $Q_1, \ldots, Q_m$, such that

$$\{P \in \mathrm{Spec}(T) \mid P \cap A = Q_i\} = \{P \in \mathrm{Spec}(T) \mid P \subseteq P' \text{ for some } P' \in \mathcal{C}_i\}$$

This talk will be accessible to those who have taken at least one semester of abstract algebra. (Received August 12, 2009)

1056-13-180 **Silvia Saccon*** (s-ssaccon1@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588-0130. *Direct-sum decompositions of modules over rings of infinite Cohen-Macaulay type.*

Given a commutative ring $R$ and a class $\mathcal{C}$ of $R$-modules, does every element of $\mathcal{C}$ decompose uniquely as a direct sum of indecomposable elements of $\mathcal{C}$? If not, is it possible for an element of $\mathcal{C}$ to decompose as the direct sum of both $s$ and $t$ indecomposable elements of $\mathcal{C}$, where $s \neq t$? I discuss these questions when $R$ is a one-dimensional reduced Noetherian local ring and $\mathcal{C}$ is the class of maximal Cohen-Macaulay $R$-modules. (Received August 12, 2009)

1056-13-196 **Angela L Kohlhaas*** (akohlhaa@nd.edu), 255 Hurley Hall, University of Notre Dame, Notre Dame, IN 46556. *The core and the adjoint: a condition for equality.*

The core of an ideal $I$ is the intersection of all ideals contained in $I$ with the same integral closure as $I$. In the Briançon-Skoda theorem, an inclusion arises between the core and certain adjoint, or multiplier, ideals. The question of when equality holds has been tied to Kawamata's conjecture about non-vanishing of sections of line bundles. I will use combinatorics to illustrate a condition for equality for certain classes of monomial ideals. (Received August 14, 2009)

1056-13-370 **Christina Eubanks-Turner*** (ceturner@louisiana.edu), **Melissa Luckas** and **Serpil Saydam** (saydam@ulm.edu). *Prime Ideals in Birational Extensions of Two-Dimensional Power Series Rings.*

In this article 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 power series rings in one indeterminate with coefficients in a principal ideal domain or in an order in an algebraic number field, where we assume that the coefficient ring has an infinite number of maximal ideals. (Received September 02, 2009)

1056-13-599 **Daniel Erman*** (derman@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94705. *Beyond Numerics in Boij-Soederberg Theory.*

Boij-Soederberg theory illustrates that the minimal free resolution of a graded module "factors" as a sum of pure resolutions. A natural question raised by this theory is: Does the numerical decomposition lead to any sort of factorization of the module itself? We will show that the answer is "yes" in a number of surprising cases. (Received September 14, 2009)

1056-13-621 **Silvia Saccon*** (s-ssaccon1@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588-0130. *Modules over one-dimensional local rings of infinite Cohen-Macaulay type.* Preliminary report.

Let $(R, \mathfrak{m})$ be a one-dimensional Noetherian local ring whose $\mathfrak{m}$-adic completion $\widehat{R}$ is reduced. We consider the monoid $\mathfrak{C}(R)$ of isomorphism classes of maximal Cohen-Macaulay $R$-modules (together with $[0_R]$) with operation given by $[M] + [N] = [M \oplus N]$. This monoid carries information about direct-sum decompositions of maximal Cohen-Macaulay $R$-modules. In order to describe $\mathfrak{C}(R)$, it is useful to consider $\mathfrak{C}(R)$ as a submonoid of $\mathfrak{C}(\widehat{R})$, since $\mathfrak{C}(\widehat{R})$ has a very simple structure by the Krull-Remak-Schmidt theorem. Fundamental in this study is the notion of *rank* of a maximal Cohen-Macaulay $\widehat{R}$-module $M$. (The rank of $M$ is the tuple consisting of the vector-space dimensions of $M_P$ over $\widehat{R}_P$, where $P$ ranges over the minimal prime ideals of $\widehat{R}$.) The key to describing $\mathfrak{C}(R)$ is to determine the possible ranks of indecomposable maximal Cohen-Macaulay $\widehat{R}$-modules. Other authors have characterized the monoid $\mathfrak{C}(R)$ when $R$ has finite Cohen-Macaulay type. In this talk, I will discuss the structure of $\mathfrak{C}(R)$ when $R$ has *infinite* Cohen-Macaulay type. (Received September 14, 2009)

1056-13-655 **M Axtell** (maxtell@stthomas.edu), Department of Mathematics, University of Saint Thomas, Saint Paul, MN 55105, **N Baeth***, Department of Mathematics and CS, WCM 222, University of Central Missouri, Warrensburg, MO 64093, and **J Stickles** (jstickles@milikin.edu), Department of Mathematics, Milikin University, Decatur, IL 62522. *Irreducible Divisor Graphs.* Preliminary report.

Recently, Coykendall and Maney introduced the concept of an irreducible divisor graph of a nonzero nonunit in an atomic domain. Given an atomic domain $D$ and some nonzero nonunit $x \in D$, the irreducible divisor graph of $x$ in $D$, denoted $G(x)$, has as vertices one representative from each associate class of irreducible divisors of $x$. Two vertices $y$ and $z$ have an edge between them if and only if $yz$ divides $x$ in $D$. Following Coykendall and Maney, we study the algebraic consequences of various graph-theoretic properties of the set of irreducible divisor graphs over an atomic domain $D$. In particular we give necessary and sufficient conditions for $D$ to be a finite factorization domain and provide examples which illustrate why this concept may not be useful for non finite factorization domains. (Received September 15, 2009)

1056-13-721 **Craig Huneke***, Department of Mathematics, University of Kansas, Lawrence, KS 66045, and **Louiza Fouli**, Department of Mathematics, New Mexico State University, Las Cruces, NM 88003. *What is a system of parameters?* Preliminary report.

We describe joint work in progress with Louiza Fouli. The basic problem comes from a result of S. Dutta and P. Roberts. Their theorem states that if $R$ is a Cohen-Macaulay local ring, $x_1, ..., x_d$ are a system of parameters, and $y_1, ..., y_d$ are d-elements inside the ideal generated by $x_1, ..., x_d$, then the map from $R/(x_1, ..., x_d)$ to $R/(y_1, ..., y_d)$ given by the determinant of a matrix of coefficients, obtained by writing each $y_j$ in terms of the $x_i$, is injective if and only if the $y_1, ..., y_d$ form a system of parameters. We discuss various extensions and generalizations of this theorem by removing the Cohen-Macaulay hypothesis. (Received September 16, 2009)

1056-13-774 **Karl Schwede*** (kschwede@umich.edu), Department of Mathematics, University of Michigan, Ann Arbor, MI 48103. *Test ideals in non-Q-Gorenstein rings.*

Given an $F$-finite reduced ring $R$ of positive characteristic $p > 0$, one can define the associated big test ideal $\tau_b(R)$. This is the ideal generated by all test elements for all tight closure operations in all modules.

If $R$ is reduced generically from a normal $\mathbb{Q}$-Gorenstein ring $R_0$ of characteristic zero, then the big test ideal $\tau_b(R)$ coincides with the multiplier ideal of $R_0$ (also reduced from characteristic zero). However, if $R_0$ is not $\mathbb{Q}$-Gorenstein, then the multiplier ideal is not (typically) defined. One way around this issue is to define multiplier ideals for pair $(R_0, \Delta)$ where $\Delta$ is a $\mathbb{Q}$-divisor on Spec $R_0$ such that $K_{R_0} + \Delta$ is $\mathbb{Q}$-Cartier.

On the other hand, inspired by the characteristic zero theory, S. Takagi defined the test ideal $\tau(R, \Delta)$ in positive characteristic for pairs $(R, \Delta)$ where $\Delta$ is an effective $\mathbb{Q}$-divisor on Spec $R$. In this talk, we will discuss the following result.

$$\tau_b(R) = \sum_{\Delta} \tau(R, \Delta)$$

where the sum is over $\Delta$ such that $K_R + \Delta$ is $\mathbb{Q}$-Cartier. This affirmatively answers a question asked by several people including Blickle, Lazarsfeld, K. Lee, and K. Smith. (Received September 17, 2009)

1056-13-800 **Paul C Roberts*** (roberts@math.utah.edu), Dept of Mathematics, University of Utah, 155 S 1400 E, Rm 233, Salt Lake City, UT 84112-0090. *Constructing Algebras from Witt vectors.*

Among the rings of mixed characteristic, rings of Witt vectors over perfect rings of positive characteristic have particularly nice properties. Let $R$ be an arbitrary ring of mixed characteristic $p$. While it may not be possible to find a nice map to a ring of Witt vectors, one can always find an $R$-algebra which is the quotient of a ring of Witt vectors modulo a non-zero-divisor. We describe methods for doing this and the perfect rings of positive characteristic that arise in this way. Finally, we discuss some connections with homological properties of the original ring $R$. (Received September 17, 2009)

1056-13-813 **Erin Chamberlain*** (chamberlain@math.byu.edu), Brigham Young University, Department of Mathematics, 263 TMCB, Provo, UT 84602. *Infinite Cohen-Macaulay posets and non-Noetherian Stanley-Reisner rings.*

We will extend the definition of a Cohen-Macaulay ring to the non-Noetherian setting using local cohomology. We will introduce a generalization of Reisner's theorem that the Stanley-Reisner ring of an infinite (but finite dimensional) poset is Cohen-Macaulay if and only if the associated simplicial complex is topologically Cohen-Macaulay. This has several applications, since in most cases it is easier to establish Cohen-Macaulayness algebraically than topologically. (Received September 17, 2009)

1056-13-835 **Steven Kleiman**, **Bernd Ulrich** and **Javid Validashti*** (jvalidas@math.ku.edu). *A numerical condition for equisingularity.* Preliminary report.

We introduce a notion of multiplicity for finitely generated modules over a Noetherian local ring as a limit superior of a sequence of normalized lengths. We show that our multiplicity can be used to detect integral dependence of modules and we study its application in characterizing numerically the equisingularity conditions. (Received September 17, 2009)

1056-13-839 **Thomas Scanlon*** (scanlon@math.berkeley.edu), University of California, Berkeley, Department of Mathematics, Berkeley, CA 94720-3840. *Infinitesimal differential Galois groups from jet spaces.*

In joint work with Rahim Moosa, I developed a theory of jet spaces of generalized Hasse differential varieties. In this talk, I will explain how these jet spaces give a precise sense to higher order linearization of general systems of difference/differential equations and how one may thereby associate infinitesimal Galois groups to such systems. (Received September 17, 2009)

1056-13-896 **Jeremiah N. Reinkoester*** (jreinkoe@math.uiowa.edu), Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52242. *Abstract Factorization into Relatively Prime Elements.* Preliminary report.

Let $D$ be an integral domain. We define a $\tau_{[\ ]}$-atom to be any nonzero, nonunit element $a$ of $D$ with no proper factorization $a = a_1 \cdots a_n$ such that $[a_i, a_j] = 1$ for $i \neq j$. We then define a $\tau_{[\ ]}$-UFD to be an integral domain such that each nonzero, nonunit element $a$ can be uniquely written, up to units, as a product of $\tau_{[\ ]}$-atoms $a = a_1 \cdots a_n$ with $[a_i, a_j] = 1$ for $i \neq j$. We explore $\tau_{[\ ]}$-UFD's with an emphasis on one-dimensional Noetherian domains and GCD domains. (Received September 18, 2009)

1056-13-901 **Olgur Celikbas*** (s-ocelikb1@math.unl.edu), University of Nebraska - Lincoln, Department of Mathematics, 311 Avery Hall, Lincoln, NE 68588–0130. *Vanishing of Tor over complete intersections.*

In this talk we are concerned with the vanishing of Tor over complete intersection rings. Building on results of C. Huneke, D. Jorgensen and R. Wiegand, and, more recently, H. Dao, we obtain new results showing that good depth properties on the $R$-modules $M$, $N$ and $M \otimes_R N$ force the vanishing of $\mathrm{Tor}_i^R(M, N)$ for all $i \geq 1$. (Received September 18, 2009)

1056-13-1203 **Bo-Yin Yang*** (by@crypto.tw), 128 Sec 2 Academia Rd, Inst. of Information Science, Taipei, 11529, Taiwan. *Multivariate Public Key Cryptography.*

A multivariate public key cryptosystem (MPKCs for short) have a set of (usually) quadratic polynomials over a finite field as its public map. Its security rests on the hardness of solving a system of nonlinear equations over a finite field, and that of finding an isomorphism between two quadratic maps. This family is considered to be one of the major families of PKCs that could resist potentially even the powerful quantum computers of the future. There has been fast and intensive research in Multivariate Public Key Cryptography in the last two decades. Some constructions are not as secure as was claimed initially, but others are still viable. We give an overview of multivariate public key cryptography and discusse the current status of the research in this area, including designs, attacks, and implementations. (Received September 21, 2009)

1056-13-1259 **Andy R. Magid*** (amagid@ou.edu), Department of Mathematics, University of Oklahoma, 601 Elm Room 423, Norman, OK 73072. *Some Problems in Galois Theory and Representation Theory.* Preliminary report.

We present some problems in a number of areas along with some partially successful and partially unsuccessful solution strategies. The problems are from Galois theory of commutative rings, algebraic group actions on commutative rings, representation varieties of groups, and differential Galois theory. (Received September 21, 2009)

1056-13-1328 **Benjamin Antieau*** (antieau@math.uic.edu), Department of Mathematics (m/c 249), University of Illinois at Chicago, 851 South Morgan Street, Chicago, IL 60607-7045, and **Alexey Ovchinnikov** (aiovchin@gmail.com). *Galois theory of difference equations with difference parameters.*

In this talk, the authors explore an application of Dima Trushin's work on difference Nullstellensatz theorems to the creation of a Galois theory of difference equations with difference parameters. This complements the works of Cassidy, Singer, and Hardouin on the Galois theory of difference and differential equations with differential parameters. However, serious ring-theoretical difficulties must be dealt with in the case where one has difference parameters. These are approached by building upon the initial idea of Trushin's difference closed rings (pseudo-fields). (Received September 21, 2009)

1056-13-1439 **Phillip A. Griffith**, Urbana, IL 61801, and **Alexandra Seceleanu*** (asecele2@illinois.edu). *Syzygy Theorem via Comparison of Order Ideals.*

The Evans-Griffith Syzygy Theorem states that the rank of a non-free $k$th syzygy of a module over a Noetherian local ring is at least $k$. In the original proof, the height of order ideals of minimal generators for syzygy modules plays a prominent role.

We introduce a comparison theorem for heights of order ideals of consecutive syzygies modulo a hyperplane section. We use this theorem and the Syzygy Theorem in equicharacteristic $p$ to prove some relevant cases of the Syzygy Theorem in mixed characteristic. In particular we prove the Syzygy Theorem in unramified mixed characteristic for syzygies of prime ideals. (Received September 22, 2009)

1056-13-1480 **Kevin Tucker*** (kevtuck@umich.edu), Department of Mathematics, University of Michigan, 2704 East University Avenue, Ann Arbor, MI 48109-1109, and **Karl Schwede** (kschwede@umich.edu), Department of Mathematics, University of Michigan, 2704 East University Avenue, Ann Arbor, MI 48109-1109. *On the Behavior of Test Ideals Under Generically Separable Finite Morphisms.*

Suppose $\pi : Y = \mathrm{Spec}(S) \to X = \mathrm{Spec}(R)$ is a generically separable finite morphism of $F$-finite normal varieties in characteristic $p > 0$. By analyzing lifting properties of $p^{-e}$-linear maps using the trace map on function fields, we are able to relate (generalized) test ideals $\tau(X, \Delta_X)$ and $\tau(Y, \Delta_Y)$ corresponding to certain divisors $\Delta_X$ and $\Delta_Y$ on $X$ and $Y$, respectively. This generalizes previously known results on the behavior of test ideals under finite morphisms which are étale in codimension one. (Received September 21, 2009)

1056-13-1484 **W. Frank Moore** and **Greg Piepmeyer*** (piepmeyerg@missouri.edu), 202 MSB, Univ. of Missouri, Columbia, Columbia, MO 65211, and **Sandra Sprioff** and **Mark E Walker**. *Hochster's Theta invariant and the Hodge-Riemann bilinear relations.*

The theta invariant is defined for certain hypersurface rings. It is a bilinear pairing on modules, and is related to Serre's intersection multiplicity.

This talk will discuss an answer to a conjecture concerning the vanishing of this invariant when the ring contains a coefficient field and is of even dimension. (Received September 21, 2009)

1056-13-1515 **Byung Gyun Kang*** (bgkang@postech.ac.kr), Dept. of Math., POSTECH, Pohang, 790-784, South Korea, and **Toan**, Dept. of Math., POSTECH, Pohang, South Korea. *Krull dimension of a power series ring over a one-dimensional nondiscrete valuation domain.* Preliminary report.

We solve an open question on the Krull dimension of a power series ring over a one-dimensional nondiscrete valuation domain posed by Eakin and Sathaye. Let V be a one-dimensional nondiscrete valuation domain and V*=V-0. We prove that dimV[[X]] loc. at V* is uncountable and that the ring V[[X]] loc. at V* is not a Prufer ring. (Received September 22, 2009)

1056-13-1522 **Byung Gyun Kang**, Department of Mathematics, Pohang University of Science and Technology, San 31 Hyoja Dong, Nam-Gu Pohang, Korea, Pohang, South Korea, and **Jung Wook Lim*** (lovemath@postech.ac.kr), Department of Mathematics, Pohang University of Science and Technology, San 31 Hyoja Dong, Nam-Gu Pohang, Korea, Pohang, 790-784, South Korea. *A general theory of almost splitting sets.*

Let $*$ be a finite type star operation on an integral domain $D$ and let $S$ be a (saturated) multiplicative subset of $D$. We generalize some results about almost splitting sets to almost g$^*$-splitting sets. (Received September 22, 2009)

1056-13-1539 **Jintai Ding** (jintai.ding@uc.edu), Department of Mathematical Sciences, University of Cincinnati, Cincinnati, OH 45221, **Timothy J Hodges*** (timothy.hodges@uc.edu), Department of Mathematical Sciences, University of Cincinnati, Cincinnati, OH 45221, and **Victoria Kruglov** (kruglov@email.uc.edu), Department of Mathematical Sciences, University of Cincinnati, Cincinnati, OH 45221. *Growth of the ideal generated by a quadratic Boolean function.* Preliminary report.

We give exact formulas for the growth of the ideal $A\lambda$ for $\lambda$ a quadratic element of the algebra of Boolean functions $A = \mathbb{F}_2[x_1, \ldots, x_n]/(x_1^2 + x_1, \ldots, x_n^2 + x_n)$ over the Galois field $\mathbb{F}_2$. That is, we calculate $\dim A_k\lambda$

where $A_k$ is the subspace of elements of degree less than or equal to $k$. For instance, if $\lambda = x_1x_2 + \cdots + x_{n-1}x_n$, then

$$\dim A_k\lambda = \begin{cases} \delta(n,k), & \text{if } 0 \le k < n/2 \\ \delta(n,k) - (\epsilon(k-n/2)+1)2^{\frac{n}{2}-1}, & \text{if } n/2 \le k \le n \end{cases}$$

where $\delta(n,k) = \sum_{i=0}^{\lfloor k/4 \rfloor} \binom{n}{k-4i} + \sum_{i=0}^{\lfloor (k-1)/4 \rfloor} \binom{n}{k-1-4i}$ and $\epsilon(k) = \cos\left(\frac{k\pi}{2}\right) + \sin\left(\frac{k\pi}{2}\right)$. These results clarify some of the assertions made in a recent article of Yang and Chen concerning the efficiency of the XL algorithm in cryptography. (Received September 22, 2009)

1056-13-1581 **Marie A Vitulli*** (vitulli@uoregon.edu), Department of Mathematics, 1222 University of Oregon, Eugene, OR 97403-1222. *A New Elementwise Criterion for Weak Subintegrality.*

Weakly subintegral extensions of commutative rings first appeared in the context of schemes in the work of Andreotti and Bombieri in 1969. An extension $A \subset B$ is weakly normal provided that the induced map Spec$(B) \to$ Spec$(A)$ is a set-theoretic bijection and all of the induced maps of residue fields $A_P/PA_P \to B_Q/QB_Q$ are purely inseparable, where $P = Q \cap A$. In the mid to late 1990s Reid, Roberts, and Singh introduced and developed a criterion for when a single element $b \in B$ is weakly subintegral over a subring $A$ of $B$. An element $b$ satisfies their condition if and only if $A \subset A[b]$ is a weakly integral extension. We provide a new elementwise criterion that is much more transparent than the original condition. We start with the case of an extension of fields and then deal with the case of a general ring extension. (Received September 22, 2009)

1056-13-1604 **Luchezar L. Avramov** (avramov@math.unl.edu), University of Nebraska, Lincoln, NE 68588, **Inês Bonacho dos Anjos Henriques*** (ihenriques@math.unl.edu), University of Nebraska, Department of Mathematics, 203 Avery Hall 880130, Lincoln, NE 68508, and **Liana M. Sega** (segal@umkc.edu), University of Missouri, Kansas City, MO 64110. *Ascent and descent modulo exact zero divisors.* Preliminary report.

An element $a$ in a commutative ring $R$ is said to be an *exact zero divisor* if it satisfies $0 \neq R/aR \cong (0 :_R a) \neq R$. It will be proved that homological and structural properties pass both ways between $R$ and $R/aR$. (Received September 23, 2009)

1056-13-1705 **Shuhong Gao*** (sgao@clemson.edu), Dept of Mathematical Sciences, Clemson University, Clemson, SC 29634, and **Yinhua Guan** (GGuan@CLEMSON.EDU), Dept of Mathematical Sciences, Clemson University, Clemson, SC 29634. *New Algorithm for Computing Grobner bases.*

Efficient computation of Grobner bases for systems of polynomials is a major challenge in computational algebra and its applications. Buchberger's algorithm was introduced in 1965, and there have been extensive efforts in improving its efficiency since then. Remarkable recent works include F4 (Faugere 1999), XL (Courtois et al. 2000), F5 (Faugere 2002), and their improvemets MutantXL (Ding et al. 2008) and F5C (Eder and Perry 2009). These algorithms have solved many large systems of polynomials thathad defied previous algorithms.

In this talk, we present a new algorithm for computing Grobner bases. Our algorithm is incremental just like the F5 algorithm. At a typical step, one is given a Grobner basis G for an ideal I and another polynomial h, it is desired to compute a Grobner basis for the new ideal (I,h), obtained from I by joining h. Let I:h denote the colon ideal of I divided by h. Our algorithm computes Grobner bases for (I,h) and I:h simultaneously. In previous algorithms, S-polynomials that reduce to zero are useless, in fact, F5 tries to avoid such reductions as much as possible. In our algorithm, however, these "useless" S-polynomials give elements in I:h and are useful in speeding up the subsequent computation. (Received September 22, 2009)

1056-13-1730 **Rachelle R. Bouchat*** (rachelle.bouchat@sru.edu), Slippery Rock University, Mathematics Department (001 Patterson Hall), 1 Morrow Way, Slippery Rock, PA 16057, and **Tài Hà** and **Augustine O'Keefe**. *The Linear Strand of Path Ideals of Trees.* Preliminary report.

Let $\Gamma = (V, E)$ be a finite, simple graph having vertex set $V = \{x_1, \dots x_n\}$ and edge set $E$. Furthermore, let $k$ be a field and identify $V$ with the variables in the polynomial ring $S := k[x_1, \dots, x_n]$. Associated to $\Gamma$ is the edge ideal $I_\Gamma \subset S$ where the minimal generating set of $I_\Gamma$ corresponds to the edge set, $E$, of $\Gamma$. Since an edge can be viewed as a path of length 1, the notion of an edge ideal can be generalized to that of a path ideal. Given a positive integer $t$, we let $I_t(\Gamma) \subset S$ be the ideal whose minimal generating set corresponds to the length $t-1$ paths in $\Gamma$. In this talk, we will develop an explicit formula for the linear strand of $S/I_t(\Gamma)$ for $t \ge 2$ where $\Gamma$ is a directed, rooted tree with a finite vertex set. (Received September 22, 2009)

1056-13-1830 **Jared L Painter*** (jlpainter@uta.edu), Department of Mathematics, University of Texas at Arlington, Arlington, TX 76019. *Comparing the Sizes of the Lower Bass Numbers of a Cohen Macaulay Local Ring.* Preliminary report.

Let $(R, m, k)$ be a local ring. The $i$th Bass number of $R$ is the number of copies of the injective envelope of $k$ in the $i$th injective module of a minimal injective resolution of $R$. In this talk we investigate the question of whether the first Bass number of a zero dimensional ring is always larger than the zeroth. In particular we look at zero dimensional rings defined by monomial ideals and show that the answer to the question is true for a large class of such rings. (Received September 22, 2009)

1056-13-1857 **William Travis Trentham*** (william.trentham@ndsu.edu), 3530 2nd Str North, Apt 19, Fargo, ND 58102. *On the Integral Closure of an Antimatter Domain.*

We recall that an atomic domain is an integral domain in which each nonzero nonunit can be expressed as a (finite) product of irreducibles. Examples of such rings would include UFD's and Noetherian domains. Sometimes we lose this "nice" property. For example, any two dimensional valuation domain with a principal maximal ideal is not atomic. However, at least such a ring would admit an atom, i.e., an irreducible. If we favor domains in which the elements can be factored nicely into irreducibles, then we find the worst kind of behavior exhibited in those domains which admit no irreducibles whatsoever. Such a ring is called an Antimatter domain (AMD). A nice characterization of the antimatter property is that a domain D is an AMD if and only if its group of divisibility admits no minimal positive elements. With this observation it becomes relatively easy to find examples of valuation domains which exhibit the antimatter property. However, valuations domains are integrally closed. In this talk we will present an example of an antimatter domain whose integral closure may admit an irreducible and we will explore the question as to whether or not the integral closure of an AMD may be atomic or even Noetherian. (Received September 22, 2009)

1056-13-1949 **Olga Holtz** (holtz@math.ias.edu), Institute for Advanced Study, School of Mathematics, Einstein Drive, Princeton, NJ 08540, **Amos Ron*** (amos@cs.wisc.edu), Department of Computer Sciences, University of Wisconsin-Madison, 1210 West Dayton street, Madison, WI 53706, and **Zhiqiang Xu**, Institute of Computational Mathematics, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Beijing, 100080, Peoples Rep of China. *Hierarchical zonotopal spaces.*

Zonotopal algebra interweaves algebraic, geometric and combinatorial properties of a given linear map $X$. Of basic significance of this theory is the fact that the algebraic structure are derived from the geometry (via the least map), and that the statistics of the algebraic structures (i.e., the various Hilbert series) are combinatorial, i.e., computable using the valuation function. On the other hand, the theory is somewhat rigid since it deals with exactly three sets of ideals for each given $X$, their three Hilbert series and so on.

In this talk, we will show that the fundamental principles of zonotopal algebra as described in the previous paragraph extend far beyond the setup of external, central and internal ideals, by developing a whole hierarchy of zonotopal spaces. (Received September 22, 2009)

1056-13-1984 **Kristen A Beck*** (kbeck@uta.edu), Box 19408, Arlington, TX 76019. *Characterizing rings which admit non-trivial totally reflexive modules.* Preliminary report.

Let $R$ be a commutative local noetherian ring, and $M$ a finitely generated $R$-module. If we let $M^*$ denote the dual of $M$, that is $M^* = \mathrm{Hom}_R(M, R)$, then $M$ is called totally reflexive if and only if

(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) the natural biduality map $\delta_M : M \to M^{**}$ is an isomorphism of $R$-modules

In this talk, we will investigate necessary and sufficient conditions for such a ring to admit non-trivial totally reflexive modules. (Received September 22, 2009)

1056-13-2006 **Anne Shiu*** (annejls@math.berkeley.edu), Dept. of Mathematics, University of California Berkeley, Berkeley, CA 94720-3840, and **Bernd Sturmfels**. *Computing siphons in biochemical reaction systems.*

In a biochemical reaction network, the concentrations of chemical species evolve in time, governed by the differential equations of mass-action kinetics. Siphons in a chemical reaction system are subsets of the species that have the potential of being absent in a steady state. This talk presents a characterization of minimal siphons in terms of primary decomposition of binomial ideals, and demonstrates the effective computation of siphons using computer algebra software. (Received September 22, 2009)

1056-13-2019 **S. D. Cutkosky**, **K. Dalili*** (dalilik@missouri.edu) and **O. Kashcheyeva**. *Asymptotic behavior of value semi-groups.*

Let $v$ be a valuation dominating a noetherian local domain, let $S = \{v(r)|r \in R\}$ be its value semi-group and let $G$ be its value group (the group obtained by appending inverses to $S$). The possible value groups $G$ have been extensively studied and classified classically; the value semi-group $S$ however is much less understood. In this talk we will briefly look at the known results classifying value groups and at some well known constraints on the value semi-groups. Then we will look at growth rate of the value semi-group and its asymptotic behavior to obtain new constraints on possible value semi-groups.

This is joint work with S. D. Cutkosky and O. Kashcheyeva. (Received September 22, 2009)

1056-13-2028 **Hamid Rahmati*** (hamid.rahmati@ttu.edu) and **Janet Striuli**. *Local rings and high syzygies.* Preliminary report.

Let $R$ be a commutative local ring and $M$ be an $R$-module. We say that $M$ is an $n$th syzygy if there is an exact sequence

$$0 \to M \to F_1 \to F_2 \to \cdots \to F_{n-1} \to F_n$$

where $F_i$ is free for all $i \geq 1$. We show that if certain $R$-modules are $n$th syzygies for $n$ large enough, it implies some nice properties of the ring $R$. (Received September 22, 2009)

1056-13-2054 **Andrew Crabbe*** (amcrabbe@syr.edu). *Building Indecomposable Modules.* Preliminary report.

A common way to understand a ring is to study certain subcategories of its modules, in particular, the indecomposable objects in such categories. Over rings with dimension 0, it's reasonable to look at the entire category of modules, however, over larger rings, its beneficial to restrict to a more tractable collection. The subcategory of greatest interest has been that of all maximal Cohen-Macaulay modules. By knowing the number of indecomposable maximal Cohen-Macaulay modules or whether there is a bound on the "size" of these modules, one can gain important information about the ring (for instance, the dimension of its singular locus). But what happens if you go away from the subcategory of maximal Cohen-Macaulay modules?

One purpose of this talk is to show that over certain rings with dimension greater than 1, one can build indecomposable modules that are arbitrarily "large" (where "large" could refer to the multiplicity, or in our case, the rank on the punctured spectrum), even if the ring does not permit the construction of arbitrarily "large" indecomposable maximal Cohen-Macaulay modules. These constructions are achieved using results for the generalized Hilbert-Samuel polynomials. (Received September 23, 2009)

# 14 ► *Algebraic geometry*

1056-14-41 **Joe Harris*** (harris@math.harvard.edu), 1 Oxford St., Cambridge, MA 02138. *The Interpolation Problem.*

A fundamental theorem in algebra says that, given two sets of complex numbers $z_0, \ldots, z_d$ and $a_0, \ldots, a_d$, there exists a unique polynomial $f(z) \in \mathbb{C}[z]$ of degree at most $d$ such that $f(z_i) = a_i$ for all $i$.

This is a beautiful and highly useful result. But when we ask the natural next question—what can we say about polynomials in several variables—we enter a realm of mystery. The analogous statement for polynomials in two or more variables is visibly false, but no one knows exactly when, and by how much, it can fail. This gives rise to a whole class of problems, collectively known as *interpolation problems*.

The interpolation problem is like a number of problems in algebraic geometry: it's completely elementary to state; a general solution seems beyond us; and yet substantial progress has been made and is currently being made. In this talk I'll try to give an elementary introduction to the problem and what we know about it. In particular, I'll try to describe a common thread in the known and conjectured solutions of special cases, giving a geometric characterization of when interpolation fails in general. (Received September 22, 2009)

1056-14-57 **Veniamin Kisunko*** (vkisunko@math.toronto.edu). *The Converse of Abel's theorem ('polynomial' and 'rational').* Preliminary report.

I investigate an algebraization problem. The analogous problems were raised by Lie and Darboux for classification of surfaces of double translation; by Poincare and Mumford in connection with the Schottky problem; by Griffiths and Henkin in connection with a converse of Abel's theorem; by Bol and Akivis for the algebraization problem in the theory of webs. Interestingly, the complex-analytic technique developed by Griftiths and Henkin for the holomorphic case failed to work in the real smooth setting. I develop a technique of, what I call, complex moments.Together with a differentiation rule it provides a unified approach to all the algebraization problems considered so far. As a result I prove two variants ('polynomial' and 'rational') of a converse of Abel's theorem which significantly generalize results of Griffiths and Henkin. Already the 'polynomial' case is nontrivial leading to a new relation between the algebraization problem in the theory of webs and the converse of Abel's theorem. But, perhaps, the most interesting is the rational case as a new phenomenon occurs: there are forms with logarithmic singularities on special algebraic varieties that satisfy the converse of Abel's theorem. I give a complete description of such varieties and forms. (Received July 23, 2009)

1056-14-152 **Amanda Knecht*** (knecht@umich.edu), University of Michigan Mathematics, 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109-1043. *Interpolation on Rational Surfaces.*

Graber, Harris, and Starr proved that if the general fiber of a fibration over a complex curve is rationally connected, then the fibration admits a section. A proper variety over $\mathbb{C}$ is rationally connected if any two points can be connected by a rational curve. Knowing that a section exists, we can ask interpolation questions about the sections. I will discuss examples of varieties for which we can find sections with prescribed Taylor series data. (Received August 05, 2009)

1056-14-153 **Carl A. Miller*** (carlmi@umich.edu), Department of Mathematics, 530 Church St., University of Michigan, Ann Arbor, MI 48109, and **Eric Chitambar**. *The geometry of multipartite quantum systems.*

A basic problem in quantum computing is to classify all possible states of a multipartite quantum system (i.e., a quantum system that is distributed between $n$ parties). In this talk we present an approach to this problem which involves algebraic geometry. The approach is based on a correspondence between states of a 3-party system and isomorphism classes of genus-zero curves with marked points. We give some new classification results. (Received August 05, 2009)

1056-14-169 **Kelly Jabbusch*** (kelly.jabbusch@math.uni-freiburg.de), Mathematics Instiute, Albert-Ludwigs University of Freiburg, Eckerstrasse 1, 79104 Freiburg, Germany, and **Stefan Kebekus**. *Families over special base manifolds and a conjecture of Campana.*

Campana defined the class of special log varieties $(Y, D)$, characterized by the fact that if $\mathcal{A} \subseteq \Omega_Y^p(\log D)$ is an invertible subsheaf for some $p$, then $\kappa(\mathcal{A}) < p$. Generalizing classical Shafarevich Hyperbolicity he conjectured that any smooth projective family of canonically polarized manifolds over a special base variety is necessarily isotrivial. I will report on joint work with Stefan Kebekus in which we prove Campana's conjecture for quasi-projective base manifolds $Y^\circ$ of $\dim Y^\circ \leq 3$. (Received August 11, 2009)

1056-14-201 **Ursula Anne Whitcher*** (ursula@math.hmc.edu), Harvey Mudd College, Dept. of Mathematics, 301 Platt Boulevard, Claremont, CA 91711. *K3 surfaces with discrete symmetry groups.*

Discrete symmetries have been used to investigate the local structure of moduli spaces of mirror families of Calabi-Yau varieties. For the two-dimensional Calabi-Yau varieties known as K3 surfaces, discrete symmetries provide a valuable tool for understanding moduli and Picard group structure. We use specific examples of K3 surfaces which admit discrete group actions to explore the implications of mirror symmetry. (Received August 14, 2009)

1056-14-212 **Kaisa E Taipale*** (taipale@math.umn.edu), 555 Vincent Hall, 206 Church St. S.E., Minneapolis, MN 55455. *The Abelian-Nonabelian Correspondence in Gromov-Witten Theory.*

Given a space $X$ acted upon "nicely" by a group $G$, the abelian-nonabelian correspondence relates the quantum cohomology rings of GIT quotients $X//G$ and $X//T$, where $T$ is the maximal torus $T \subset G$. In my poster, I will introduce the abelian-nonabelian correspondence and its K-theoretic counterpart, and present results on the extension of these results to quantum K-theory. (Received August 15, 2009)

1056-14-220 **Weronika J Buczynska*** (nisiabu@math.tamu.edu). *Toric models of graphs.*

The binary symmetric Markov statistical model of evolution on a trivalent tree is a projective toric variety, naturally defined in terms of the semigroup of networks of paths on the tree. This semigroup may be defined for any trivalent graph, and we call the associated toric variety the toric model of that graph. The poster will explain this background, present an application to differential geometry: and our main result, that models of graphs with the same numbers of leaves and cycles are deformation equivalent. (Received August 15, 2009)

1056-14-396 **Chris Hillar**, **Luis García-Puente**, **Abraham Martín del Campo**, **James Ruffo**, **Stephen L. Johnson** and **Zach Teitler*** (zteitler@tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843, and **Frank Sottile**. *Experimentation at the Frontiers of Reality in Schubert Calculus.*

We describe the setup, design, and running of an experiment utilizing a supercomputer that is helping to formulate and test conjectures in the real Schubert calculus. Largely using machines in instructional computer labs during off-hours and University breaks, it has consumed in excess of 350 GigaHertz-years of computing in its first six months of operation, solving over 1.1 billion polynomial systems. This experiment can serve as a model for other large scale mathematical investigations. (Received September 04, 2009)

1056-14-424 **Raman Sanyal**, **Frank Sottile** and **Bernd Sturmfels*** (bernd@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94720. *Orbitopes.*

An orbitope is the convex hull of an orbit of a real algebraic representation of a compact Lie group. The primary examples of such groups appearing in this lecture are the special orthogonal groups SO(n) and direct products of these. Orbitopes exhibit a rich geometric structure which connects three branches of mathematics: classical convexity, algebraic geometry and optimization theory. We present several interesting examples, including coadjoint orbitopes, Caratheodory orbitopes and Grassmann orbitopes. For each of these orbitopes we examine its algebraic boundary, its facial structure, and its representability as a spectrahedron or projection of a spectrahedron. (Received September 06, 2009)

1056-14-447 **David Jensen*** (djensen@math.utexas.edu), 620 W 51st St, Apt #201, Austin, TX 78751. *Rational Fibrations of $\overline{M_{g,1}}$.*

The moduli spaces of curves have proven themselves to be important objects of study in algebraic geometry. Unfortunately, these spaces are notoriously difficult to describe. One approach to studying them might be to construct maps from the moduli space to other objects that we could perhaps describe explicitly. It is known, however, that the moduli space $\overline{M_{g,n}}$ admits no non-trivial fibrations that are everywhere defined. In this talk, we describe naturally occurring rational fibrations of $\overline{M_{5,1}}$ and $\overline{M_{6,1}}$, and examine some consequences for the birational geometry of these spaces. (Received September 08, 2009)

1056-14-477 **Johannes Buchmann**, **Jintai Ding** and **Mohamed Saied Emam Mohamed*** (mohamed@cdc.informatik.tu-darmstadt.de), Technische Universitaet Darmstadt,Fachbereich, Informatik, Kryptographie und Computer Algebr, Hochschulstrasse 10, Darmstadt, Hessen 64289, and **Wael Said Abd Elmageed Mohamed** and **Daniel Cabarcas**. *MutantXL: An Efficient Algorithm for Solving Multivariate Polynomial Equations.*

MutantXL is an algorithm for solving systems of polynomial equations that was proposed at SCC 2008 and improved in PQC 2008. This talk shows how the concept of mutants can be used to speed up the XL algorithm. The MutantXL algorithm is a new and very efficient alternative to solve multivariate polynomial equations on the function ring over $\mathbb{F}_2$. This talk also introduces a new efficient algorithm for computing Gröbner bases of zero-dimensional ideals called $MXL_3$. The $MXL_3$ is based on MutantXL algorithm, $MXL_2$ improvements, and a new sufficient condition for a set of polynomials to be a Gröbner basis. The experiments showed that both in classical cryptographic challenges and random systems, $MXL_3$ algorithm performs substantially better than the $F_4$ algorithm implemented in Magma, currently the best publicly available implementation of $F_4$. (Received September 12, 2009)

1056-14-524 **Anthony Licata*** (amlicata@math.stanford.edu), Dept. of Mathematics, Stanford University, stanford, CA 94305, and **Sabin Cautis** and **Joel Kamnitzer**. *Categorification via Quiver Varieties.*

H. Nakajima gave a geometric construction of representations of Kac-Moody algebras using cohomology of quiver varieties. We categorify this construction using derived categories of coherent sheaves on quiver varieties. (Received September 11, 2009)

1056-14-624 **Alex L Castro*** (alcastro@ucsc.edu), 1156 High Street, Mathematics Department, 194 Baskin Engineering, Santa Cruz, CA 95064, and **Richard Montgomery** and **Michail Zhitomirskii**. *Space Curve Singularities and the Semple Tower.* Preliminary report.

Cartan introduced the method of prolongation which can be applied either to manifolds with distributions (Pfaffian systems) or integral curves to these distributions. Repeated application of prolongation to a $n$-manifold endowed with its tangent bundle yields the Monster tower, or *Semple tower* a sequence of manifolds, each a $\mathbb{R}P^{n-1}$-bundle over the previous one, each endowed with a rank $n$ distribution.

Symmetries of these geometric manifolds, for $n \geq 3$, come from iterated prolongations of local diffeomorphisms of $\mathbb{R}^n$. The philosophy driving the current work is that all questions regarding the Semple tower can be reduced to problems regarding germs spatial curve singularities.

Here we establish a canonical correspondence between points of the Semple tower and finite jets of spatial curves. We show that each point of the Semple tower can be realized by evaluating the $k$-fold prolongation of an analytic spatial curve germ. Singular points arise from singular curves.

Our main results consist of classifying points in the Semple tower up to symmetry. This has been achieved for orbits of low codimension.

Time permitting we shall also touch upon some open problems. (Received September 14, 2009)

1056-14-642 **David J Swinarski*** (davids@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602. *Equations of curves with automorphisms.* Preliminary report.

Curves with automorphisms often provide important special examples for study in algebraic and arithmetic geometry. Unfortunately, there is not yet a general algorithm for writing equations for a curve with a given automorphism group. I will use a combination of representation theory and invariant theory to give equations for a few small genus examples which are of interest both in geometric invariant theory and in studying Jacobians of curves. (Received September 15, 2009)

1056-14-944 **Christine Berkesch*** (cberkesc@purdue.edu), Purdue University, Department of Mathematics, 150 North University Street, West Lafayette, IN 47907. *The rank of a hypergeometric system.*

An A-hypergeometric system is a system of PDEs determined by a toric ideal and certain homogeneity parameters. The dimension of its solution space, called its rank, is constant for generic parameters. I will discuss the combinatorial nature of this rank at non-generic parameters and its ties to the local cohomology of the toric algebra with support in the maximal ideal. (Received September 18, 2009)

1056-14-971 **Chirag M Lakhani*** (cmlakhan@ncsu.edu), 604D Smedes Pl., Raleigh, NC 27606. *GIT Compactification of the Quintic Threefolds.*

Quintic threefolds are some of the simplest examples of Calabi-Yau varieties. An interesting relationship, discovered by string theorists, is that every Calabi-Yau variety $X$ has a mirror Calabi-Yau variety $Y$. In fact mirror symmetry is a relationship which relates complex structure moduli space of $X$ to the complexified Kahler moduli of it's mirror $Y$. In this talk I will describe the complex structure moduli space from the point of view of GIT. In particular, I will discuss singularities which occur in this moduli space and their relationship to mirror symmetry. (Received September 20, 2009)

1056-14-982 **Raymond A. Heindl*** (rheindl@gmail.com). *Multivariate Public Key Cryptosystems from Diophantine Equations.*

Most public key cryptosystems used in practice are based on integer factorization or discrete logarithms (in finite fields or elliptic curves). However, if large enough quantum computers can be built, Shor's algorithm will render them completely insecure. Multivariate public key cryptosystems (MPKC) are one possible alternative. MPKC makes use of the fact that solving multivariate polynomial systems over a finite field is an NP-complete problem, for which it is not known whether there is a polynomial algorithm on quantum computers. In this talk, we give a brief introduction to the area, and we propose a new multivariate public key encryption scheme that is based on Diophantine equations. (Received September 19, 2009)

1056-14-1120 **Daniel J. Bates*** (bates@math.colostate.edu), Department of Mathematics, 101 Weber Building, Colorado State University, Fort Collins, CO 80523, and **Jonathan D. Hauenstein**, **Tim McCoy**, **Chris Peterson** and **Andrew J. Sommese**. *Recovering exact results from numerical computation in algebraic geometry.*

Many problems in algebraic geometry can be studied via symbolic computation, typically based on the computation of one of more Groebner bases. Another option in many cases is numerical computation, typically rooted in homotopy continuation. Symbolic methods provide exact results but suffer from some complexity issues. Numerical methods are often more efficient but provide inexact output.

The focus of this talk is a new technique to move from exact input through inexact computations to exact output. In particular, given an ideal I of polynomials with rational coefficients, standard numerical methods will produce witness points (approximations of generic points) on each irreducible component of the algebraic set V(I). Given that information, lattice basis reduction algorithms such as LLL can be employed to find generators of the ideals corresponding to each irreducible component. These results can then be verified by (inexpensive) symbolic methods. This new method combines the efficiency of numerical computation with the certainty of symbolic computation. (Received September 21, 2009)

1056-14-1126 **Jim Carrell***, Department of Mathematics, University of British Columbia, Vancouver,, BC V6T 1Z2. *On a remarkable formula of Kostant and Macdonald, pattern avoidance and smoothness of Schubert varieties in ageneralized flag variety.*

A remarkable formula due to Bert Kostant and Ian Macdonald relates the exponents of a semisimple complex algebraic group $G$ to the number of positive roots of height $i$ for each $i$ between 1 and the height of the highest root. The purpose of this talk is to recall this formula and revisit a generalization to smooth Schubert varieties in the flag variety $G/B$ of $G$ due to the author and E. Akyildiz (Proc. Nat. Acad. Sci. U.S.A. 86 (1989), 3934–3937). This turns out suggest an extremely simple algebraic citerion for smoothness of a rationally smooth Schubert variety: namely, as long as $G$ doesn't contain any $G_2$ factors, then a rationally smooth Schubert variety $X$ in $G/B$ is smooth if and only if the dimension of the linear span of the reduced tangent cone to $X$ at the identity coset equals the dimension of $X$. (Received September 21, 2009)

1056-14-1155 **Seth Sullivant*** (`smsulli2@ncsu.edu`), Department of Mathematics, Raleigh, NC 27695. *Algebraic geometry of Gaussian graphical models.*

Gaussian graphical models are parametrically defined semialgebraic subsets of the cone of positive definite matrices. Their Zariski closures generalize familiar varieties in combinatorial algebraic geometry including toric varieties, secant varieties, and matrix Schubert varieties. I will report on some recent results towards understanding the implicit descriptions of these models. (Received September 21, 2009)

1056-14-1157 **Erich Leo Kaltofen*** (`kaltofen@math.ncsu.edu`), Dept. Mathematics, Campus Box 8205, North Carolina State University, Raleigh, NC 27690-8205, and **Zhengfeng Yang** and **Lihong Zhi**. *ArtinProver: a truly hybrid symbolic/numeric global optimization algorithm.* Preliminary report.

ArtinProver is an algorithm that computes a numeric fraction of polynomial sums-of-squares (SOS) for a positive semi-definite (PSD) polynomial or rational function and then converts the SOS/SOS into an exact identity with rational coefficients. We will report on progress made in the last year on both the numeric semi-definite programming and the rationalization step to solve several examples from the SOS literature and other polynomial inequalities presented to us. We have proved the Monotone Column Permanent Conjecture for dimension four and found accurate bounds for Rump's model problem as far as factor degree 17. We also will present ideas on PSD polynomials with numeric coefficients and examine the role of Sturmfels's rational SOS conjecture for PSD polynomials with rational coefficients.

This is joint work with our students Feng Guo and Sharon Hutton. (Received September 21, 2009)

1056-14-1166 **Hal Schenck*** (`schenck@math.uiuc.edu`), Math Dept, 1409 W. Green St., UIUC, urbana, IL 61801. *Piecewise polynomials and equivariant Chow cohomology of nonsimplicial toric varieties.* Preliminary report.

For a toric variety $X_\Sigma$ determined by a polyhedral fan $\Sigma$, we give a formula for the third Chern class of the equivariant Chow cohomology. The first two Chern classes depend only on the combinatorics of $\Sigma$, but $c_3$ depends on the geometry of codimension two intersections of facets of $\Sigma$. (Received September 21, 2009)

1056-14-1178 **Jonathan D Hauenstein*** (`jhauenst@fields.utoronto.ca`), 222 College St, Toronto, Ontario M5T 3J1, Canada. *Computing Hilbert functions using dual bases.* Preliminary report.

Dual bases, based on Macaulay's inverse systems, are used in many computations in algebraic geometry, including multiplicity, local dimension, and primary components. After introducing dual bases and some computations involving them, this talk will describe an algorithm that uses a dual basis to compute the Hilbert function and dimension of a homogeneous ideal. Parallelizing this algorithm will also be discussed. (Received September 21, 2009)

1056-14-1317 **Bertrand Eynard**, **Motohico Mulase** and **Brad Safnuk*** (`brad.safnuk@cmich.edu`), Mathematics Department, Central Michigan University, Mt Pleasant, MI 48858. *The Laplace transform of the cut-and-join equation and the Bouchard-Marino conjecture on Hurwitz numbers.*

We calculate the Laplace transform of the cut-and-join equation of Goulden, Jackson and Vakil. The result is a polynomial equation that has the topological structure identical to the Mirzakhani recursion formula for the Weil-Petersson volume of the moduli space of bordered hyperbolic surfaces. We find that the direct image of this

Laplace transformed equation via the inverse of the Lambert W-function is the topological recursion formula for Hurwitz numbers conjectured by Bouchard and Marino using topological string theory. (Received September 21, 2009)

1056-14-1407 **Henri Gillet**, **Sergey Gorchinskiy** and **Alexey Ovchinnikov***, City University of New York, Queens College, Department of Mathematics, 237 Kiely Hall, 65-30 Kissena Blvd, Flushing, NY 11367. *Geometry of differential Tannakian categories.*

The Galois theory for systems of linear differential equations with parameters developed by Cassidy and Singer requires the field of constants of the base field to be differentially closed. In the language of Tannakian categories, the latter extra condition was used to show the existence of a differential fibre functor that computes solutions of the system. Using techniques from algebraic geometry, Atiyah extensions, we show how to construct a differential fibre functor for a large class of base differential fields not requiring the constants to be differentially closed. (Received September 21, 2009)

1056-14-1419 **Matthew J. Menickelly*** (menickmj@muohio.edu), 1010 Arrowhead Dr., Oxford, OH 45056, and **Katharina M. Carella** (k.m.carella@gmail.com), 208 Pennsylvania Ave., Ithaca, NY 14850. *Sudoku, Shidoku, and . . . Gröbner Bases? An Algebraic and Computer Systems Approach to Counting Equivalent Puzzles.* Preliminary report.

Sudoku, and its smaller counterpart, Shidoku, have been studied to try to determine the conditions that lead to a unique completion of a given incomplete puzzle. In this talk, we consider instead the number of possible solution boards from incomplete puzzles. We present the algebraic group derived from symmetries of Shidoku boards. We then use this group to define equivalent puzzles in terms of the orbits of set elements under these group actions to classify all possible numbers of solutions from incomplete puzzles. We use Gröbner Basis representations of Shidoku and Sudoku to obtain these results. Ultimately, we provide a complete classification of all the possible number of solutions that can result from incomplete Shidoku puzzles. (Received September 21, 2009)

1056-14-1473 **Ahmet Emin Tatar*** (atatar@math.fsu.edu), 356 Pennell Circle Apt 8, Tallahassee, FL 32310. *Tensor Product of Picard Stacks.*

In SGA4 Exposé XVIII, Deligne constructs an algebraic model for the 2-category of Picard stacks in terms of length 2 complexes of abelian sheaves. He uses this model to define the tensor product of Picard stacks. He also proves that this tensor product has a similar universal property as the tensor product of modules. In this talk, we will generalize Deligne's work to Picard 2-stacks. We will first construct an algebraic model for the 3-category of Picard 2-stacks which we will then use to define the tensor product of Picard 2-stacks. (Received September 21, 2009)

1056-14-1723 **Damiano Testa** (adomani@gmail.com), Mathematical Institute, 24-29 St Giles', Oxford, TX OX1 3LB, **Anthony Varilly-Alvarado*** (varilly@rice.edu), Mathematics Depatrment, MS136, Houston, TX 77005, and **Mauricio Velasco** (velasco@math.berkeley.edu), Department of Mathematics, Evans Hall, Berkeley, CA 94720. *Cox rings of big rational surfaces.*

The Cox ring, or total coordinate ring, of an algebraic variety is the object of much recent work in both algebraic geometry and number theory. For example, the Cox rings of del Pezzo surfaces, have been used to count points of bounded height on these surfaces and thus verify instances of a deep conjecture of Batyrev and Manin. Determining which varieties have a finitely generated Cox ring is a notoriously difficult problem, even in the case of surfaces. We will show that the class of smooth projective rational surfaces with big anticanonical class has a finitely generated Cox ring. We will also present some systematic collections of examples of these surfaces. (Received September 22, 2009)

1056-14-1743 **David Eisenbud*** (de@msri.org), Dept of Mathematics, University of California, Berkeley, Berkeley, CA 94720, and **Frank-Olaf Schreyer**. *Sheaves on $P^1 \times P^1$.*

We described the cone of cohomology tables of coherent sheaves on $P^n$ in our paper Cohomology of Coherent Sheaves and Series of Supernatural Bundles (arXiv:0902.1594; to appear in the Journal of the European Mathematical Society.) This talk will explain ideas from our recent joint work on a possible description of the cone of bigraded cohomology tables of vector bundles on $P^1 \times P^1$. (Received September 22, 2009)

1056-14-1933 **Christopher Lyons*** (clyons@caltech.edu), Department of Mathematics 253-37, California Institute of Technology, Pasadena, CA 91125. *Algebraic cycles and degenerations for a class of surfaces of general type.*

From an arithmetic standpoint, surfaces of general type have received much less attention than their counterparts of lower Kodaira dimension. We describe work on a class of surfaces of general type over $\mathbb{C}$ with invariants $p_g = q = 1$ and $K^2 = 3$, first classified by Catanese and Ciliberto. All such surfaces (or rather their canonical models) belong to an algebraic family over a connected base.

We indicate how a preliminary picture of degenerations of the smooth fibers in this family implies that an underlying monodromy representation coming from the 2nd singular cohomology has large image. This immediately implies that the generic Picard number of these surfaces is 2. If the surface is defined over a number field then, in most cases, it may also yield results about the Galois representation on its 2nd $\ell$-adic cohomology, such as the Tate Conjecture. (Received September 22, 2009)

1056-14-2079 **Andrew Sommese*** (sommese@nd.edu), Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556-4618. *Zebra Fish, Tumor Growth, and Algebraic Geometry.*

Problems of central importance in engineering and science often lead to systems of partial differential equations, for which the only hope of solution is to compute numerical solutions. Often the systems are intrinsically nonlinear with several solutions corresponding to the same set of physical conditions. Discretizations of such systems of differential equations often lead to large systems of polynomial equations whose solutions correspond to potential solutions of the system of differential equations. These naturally arising polynomial systems are well beyond the pale of systems previously investigated in numerical algebraic geometry.

This talk will describe some of the recent work of Wenrui Hao, Jonathan Hauenstein, Bei Hu, Yuan Liu, Yong-Tao Zhang, and myself in successfully solving such systems arising in pattern formation and tumor growth. (Received September 23, 2009)

# 15 ► Linear and multilinear algebra; matrix theory

1056-15-78 **Duy D Nguyen*** (duy.nguyen@tcu.edu), 11480 Audelia Road APT. #343, Dallas, TX 75243, **Katelyn L McCall** (katelyn.mccall@rochester.edu), 8 Borrowby Circle, Princeton, NJ 08540, **Laura J Buggy** (ljbuggy@csbsju.edu), 14508 Woodhill Circle, Minnetonka, MN 55345, **Amalia V Culiuc** (culiu22a@mtholyoke.edu), 1682 Blanchard, 50 College St, South Hadley, MA 01075, and **Sivaram K Narayan** (sivaram.narayan@cmich.edu), Department of Mathematics, Central Michigan University, Mount Pleasant, MI 48859. *The Energy of Graphs and Matrices.*

Let $G$ be a finite, undirected, and simple graph. If $\{v_1, \cdots, v_n\}$ is the set of vertices of $G$, then the *adjacency matrix* $A(G) = [a_{ij}]$ is an *n-by-n* matrix where $a_{ij} = 1$ if $v_i$ and $v_j$ are adjacent and $a_{ij} = 0$ otherwise. The *energy* of a graph, $E(G)$, is defined as the sum of the absolute values of eigenvalues of $A(G)$. The concept of energy originates in chemistry and was first defined by I. Gutman in 1978. It has been generalized recently as follows: For a graph $G$ on $n$ vertices, let $M$ be a matrix associated with $G$. Let $\mu_1, \cdots, \mu_n$ be the eigenvalues of $M$ and let $\bar{\mu}$ be the average of $\mu_1, \cdots, \mu_n$. The more general *$M$-energy of $G$* is then defined as:

$$E_M(G) = \sum_{i=1}^{n} |\mu_i - \bar{\mu}|.$$

In this talk we present our results on graph energy when $M$ is the Laplacian matrix, the signless Laplacian matrix, or the distance matrix. In particular we give bounds for energy of different graph classes and study the effect of edge deletion. (Received July 22, 2009)

1056-15-185 **Daniel E Poore*** (daniel.poore@pomona.edu), 170 E 6th St Suite 132 Box 283, Claremont, CA 91711. *Analytic Properties of Unitary Equivalence to Constant Diagonal Matrices.* Preliminary report.

It is a well know fact that any matrix is unitaryily equivalent to a matrix with constant diagonal entries. However, current proofs of this are only existential, and provide no assistance in actually constructing such a matrix. We derive an explicit algorithm of $O(n)$ steps for finding a unitary that performs such a change. We also show that as a fucntion mapping matrices to corresponging unitaries, this algorithm is continuous on an open, dense, subset of $\mathbb{M}_n$. Furthermore, we examine generic points of discontinuity of all such functions, and construct a finite set of functions such that at least one is continuous whereever possible. (Received August 13, 2009)

1056-15-355 **Emily McHenry*** (mchenrye@xavier.edu) and **Robert Lang** (rlang6@fau.edu). *Inverse Inertia Problem for Graphs.*

Let $G$ be an undirected graph on $n$ vertices and let $S(G)$ be the set of all real symmetric $n \times n$ matrices whose nonzero off-diagonal entries occur in exactly the positions corresponding to the edges of $G$. The minimum rank problem for $G$ is to determine the smallest possible rank, $\mathrm{mr}(G)$, of a matrix in $S(G)$. It has been an active area of research for a decade. The inverse inertia problem for a graph, a refinement of the minimum rank problem, asks which inertias can be attained by a matrix in $S(G)$.

The inverse inertia problem has been completely solved for trees in a paper by Barrett, Hall, and Loewy. We develop a number of new techniques in order to be able to determine possible inertias of general graphs: covers with cliques, covers with cliques and clique-stars, and the graph operations of edge subdivision, edge deletion, joins, and unions. Our results are strong enough to determine the inertia set of each graph on 6 or fewer vertices and can be applied to many graphs with larger order as well. (Received September 01, 2009)

1056-15-394 **Junsheng Fang**, **David Larson** and **Stephen Rowe*** (srowe12@gmail.com), 1190 Main Street, Box 212, Jupiter, FL 33458. *On Property $P_1$ and Spaces of Operators.* Preliminary report.

A problem posed by David Larson asks whether every subspace with property $P_1$ is two-reflxive, or equivalently, is its preannihilator the closed span of rank $\leq 2$ operators. A space of operators $S, \subseteq M_n(\mathbb{C})$, is said to have property $P_1$ if every element of $M_n(\mathbb{C})$ can be written as a rank-1 matrix plus an element of the preannihilator of $S$. The preannihilator, $S_\perp$, is the set of all operators, $f$, such that $Tr(fs) = 0 \quad \forall s \in S$. We investigate the structure of spaces that have property $P_1$. We say an algebra $A$ is a maximal $P_1$ algebra if there does not exist any algebra containing $A$ that also has property $P_1$. We show that semi-simple algebras always have property $P_1$ and that when $A \subset M_n(\mathbb{C})$ is a semi-simple algebra with dimension $n$, then $A$ is a maximal $P_1$ algebra. (Received September 03, 2009)

1056-15-935 **Elizabeth J. Bodine*** (ebodine@math.wsu.edu), Department of Mathematics, Washington State University, Box 643113, Pullman, WA 99164-3113, and **Judith J. McDonald** (jmcdonald@math.wsu.edu), Department of Mathematics, Washington State University, Box 643113, Pullman, WA 99164-3113. *Spectrally arbitrary patterns of matrices over finite fields.*

A zero-nonzero pattern $\mathcal{A}$ is spectrally arbitrary over a finite field $\mathbb{F}_q$ provided that for each monic polynomial $r(x) \in \mathbb{F}_q[x]$, there exists a matrix $A$ over $\mathbb{F}_q$ with zero-nonzero pattern $\mathcal{A}$ such that the characteristic polynomial $p_A(x) = r(x)$. This is analogous to the study of spectrally arbitrary patterns over $\mathbb{R}$, but yields some very different results that rely heavily on the structure of finite fields. In this talk, we will investigate several zero-nonzero patterns and identify over which finite fields these patterns are spectrally arbitrary. (Received September 18, 2009)

1056-15-1076 **Aaron Welters*** (awelters@math.uci.edu), Department of Mathematics, University of California, Irvine, CA 92697. *On Constructibility Results for a Class of Non-Selfadjoint Analytic Perturbations of Matrices with Degenerate Eigenvalues.*

In this talk, I consider the problem of finding explicit recursive formulas to compute the perturbed eigenvalues and eigenvectors of non-selfadjoint analytic perturbations of matrices with degenerate eigenvalues. Based on some math-physics problems arising from the study of slow light in photonic crystals, we single out a class of perturbations that satisfy what I call the generic condition. It will be shown that for this class of perturbations, the problem mentioned above of finding explicit recursive formulas can be solved. Using these recursive formulas, I will list the first and second order terms for the perturbed eigenvalues and eigenvectors of perturbations belonging to this class. (Received September 20, 2009)

1056-15-1159 **Mathias Drton*** (drton@uchicago.edu), Department of Statistics, University of Chicago, 5734 S. University Ave, Chicago, IL 60637, and **Josephine Yu**. *On a parametrization of positive semidefinite matrices with zeros.*

We study a class of parametrizations of convex cones of positive semidefinite matrices with prescribed zeros. Each such cone corresponds to a graph whose non-edges determine the prescribed zeros. Each parametrization in the class is a polynomial map associated with a simplicial complex comprising cliques of the graph. The images of the maps are convex cones, and the maps can only be surjective onto the cone of zero-constrained positive semidefinite matrices when the associated graph is chordal. Our main result gives a semi-algebraic description of the image of the parametrizations for chordless cycles. The work is motivated by the fact that the considered maps correspond to Gaussian statistical models with hidden variables. (Received September 21, 2009)

1056-15-1162 **Duk-Sun Kim*** (mass@skku.edu), Department of Mathematics, Chun-Chun Dong 300, Jang-An Gu, Suwon City, Kyoung-Ki Do., Suwon, Kyoung-Ki 440-746, South Korea, and **Sang-Gu Lee** (sglee@skku.edu), Sungkyunkwan University, Chun-Chun Dong 300, Jang-An Gu, Suwon City, Kyoung-Ki Do., Suwon, Kyoung-Ki 440-746, South Korea. *An analysis of the singular values from the binary information with its preserver and patternization.*

Singular values have represented important properties in the image and sound data. Those values can be used to find a method to determine some patterns in the given image and sound data. In this talk, we introduce how we can determine the difference of the binary data from multimedia resources, singular value decomposition(SVD) plays an important role in this signal processing. (Received September 21, 2009)

1056-15-1231 **Elisha Peterson*** (elisha.peterson@usma.edu), MADN-Math, United States Military Academy, 646 Swift Road, West Point, NY 10996. *Unshackling Linear Algebra from Linear Notation.*

Have you ever seen one of those movies where the hero unearths an artifact covered with mysterious symbols, and it takes a brilliant scientist to decipher their meaning? Hollywood's tacit (and reasonable) assumption is that the mathematics of a different civilization would look very different. This talk is an accessible introduction to trace diagrams, a non-traditional notation for linear algebra that could plausibly have been developed by another civilization. Surprisingly, the notation is perfectly rigorous, and often leads to proofs more elegant than those written using traditional notation. The only prerequisite is an understanding of basic linear algebra and a willingness to work some examples to get used to doing real math with "doodles". (Received September 21, 2009)

1056-15-1428 **Zhexiu Tu*** (tuzhexiu@gmail.com), Bard College, P.O. Box 5000, Annandale-on-Hudson, NY 12504, and **Olivia Walch**. *Minimal Sufficient Sets and the Commutativity of Patterns.*

In this research, we discuss the commutativity problem of matrix theory on the commutant of matrices in patterns by studying the minimal sufficient set of the commutant. We prove that there always exists a minimal sufficient set for commutant of any given matrix and try to find a universal minimal sufficient set for the commutant of matrices in a certain pattern. We start by considering the commutant of matrices in tridiagonal pattern, and then that of matrices in star(arrow) pattern. We conclude that only commutant of tridiagonal matrices has a universal minimal sufficient set. (Received September 21, 2009)

1056-15-1823 **Lek-Heng Lim*** (lekheng@math.berkeley.edu), 873 Evans Hall, Berkeley, CA 94720-3840. *Multilinear Algebra in Signal Processing.*

Multilinear algebra often arises in the analysis of multivariate non-Gaussian signals via *cumulants*. These are symmetric tensors measuring various statistical properties, e.g. the first four cumulants measure mean, variance, skewness, and kurtosis respectively. For a signal generated by a Gaussian process, the first two cumulants characterize it completely; for signals from non-Gaussian processes, one needs higher-order cumulants as well.

We look at two ways to analyze symmetric tensors that are in some sense generalizations of the spectral theorem for symmetric matrices. (1) *Secants of Veronese variety*: decomposing a homogeneous polynomial into a linear combination of powers of linear forms; (2) *Symmetric subspace variety*: decomposing a symmetric hypermatrix into a multilinear combination of points on a Stiefel manifold. We propose a PCA-like technique that identifies "principal cumulant components" accounting for variations in all cumulants via optimization over a single Grassmannian.

We will interpret signal processing broadly, including not just communication signals but also anything from biological signals of cellular activities to chemical signals of ecological activities to financial signals of market activities. (Received September 22, 2009)

1056-15-2082 **Misha Kilmer** and **Carla D Martin*** (martincd@jmu.edu), Department of Mathematics & Statistics, MSC 1911, James Madison University, Harrisonburg, VA 22807. *Factorization Strategies for Tensors.*

Operations with tensors, or multiway arrays, have become increasingly prevalent in recent years. Traditionally, tensors are represented or decomposed as a sum of rank-1 outer products. Such decompositions are motivated by specific applications where the goal is to find an approximate such representation for a given multiway array. The specifics of the approximate representation depend on the application.

In this talk, we explore an alternate representation of tensors which shows promise with respect to the tensor approximation problem. Specifically, we explore a new type of representation of tensors as products of tensors which is reminiscent of matrix factorization methods. In order to introduce this new notion, we define tensor-tensor multiplication in such a way so that it is closed under this operation. This new multiplication allows us to introduce concepts such as tensor transpose, inverse, and identity, which lead to a notion of an orthogonal tensor. Our definitions are derived for order three tensors, but have the advantage they can be extended to the order-p p > 3 case. A major motivation for considering this new type of tensor multiplication is to devise new types of factorizations for tensors which can then be used in applications. (Received September 23, 2009)

# 16 ► *Associative rings and algebras*

1056-16-112 **Gangyong Lee*** (lgy999@math.osu.edu), 231 W. 18th Ave, MA 332, Mathematics, OSU, Columbus, OH 43210, **S. Tariq Rizvi** (Rizvi.1@osu.edu), 4240 Campus Drive, Mathematics, Lima, OH 45804, and **Cosmin S Roman** (cosmin@math.osu.edu), 4240 Campus Drive, GA 420L, Mathematics, Lima, OH 45804. *Idempotents and Annihilators in Endomorphism Rings of Modules.* Preliminary report.

Let $M$ be a right $R$-module and set $S = End_R(M)$. $M$ is called a *Rickart module* if the right annihilator in $M$ of any single element of $S$ is generated by an idempotent in $S$, equivalently, $\forall \varphi \in S$, $Ker\varphi \leq^{\oplus} M$.

$M$ is called a *dual-Rickart module (or d-Rickart module)* if the image in $M$ of every endomorphism of $S$ is generated by an idempotent in $S$, equivalently, $\forall \varphi \in S$, $Im\varphi \leq^{\oplus} M$.

In this talk, we will discuss properties of these two concepts and explore connections between them. Various examples and results will be presented.

(This is a joint work with S. Tariq Rizvi and Cosmin Roman. It is a Preliminary Report.)

(Received July 28, 2009)

1056-16-129 **Radoslav M. Dimitric*** (rdimitric@juno.com), Pittsburgh, PA. *ON DUALIZING THE NOTION OF SLENDERNESS.* Preliminary report.

Let $C$ be an additive category with infinite coproducts $\coprod$. There are a number of ways to dualize the well-known notion of slenderness. The most correct one is the following: An object $M \in Obj\,C$ is called a *coslender object* if, for every family of objects $\{A_n : n \in \mathbb{N}\}$, and every morphism $f : M \longrightarrow \coprod A_n$, there are morphisms $f_{n_i} : M \longrightarrow A_{n_i}$, $i \in \{1, 2, \ldots, k\} \subset \mathbb{N}$, such that $f = \sum_{i=1}^{k} p_{n_i} f_{n_i}$, where $p_{n_i} : A_{n_i} \longrightarrow \coprod A_n$ are the natural coproduct morphisms (the notion is essentially due to Mitchell (1965) and Rentschler (1969) under the names of "small" and "Σ-type" respectively). I will examine some notions of coslenderness and will look in particular into conditions and consequences when and if the countable index set $\mathbb{N}$ may be replaced by an arbitrary index set. (Received July 28, 2009)

1056-16-339 **Gonzalo Aranda Pino*** (g.aranda@uma.es), Department of Algebra, Geometry and Topology, University of Málaga, 29071 Málaga, Málaga, Spain, and **Kulumani Rangaswamy** and **Mercedes Siles Molina**. *Weakly regular and self-injective Leavitt path algebras.*

In this talk we will characterize the Leavitt path algebras over arbitrary graphs which are weakly regular rings as well as those which are self-injective. Concretely we will show the following:

Let $E$ be an arbitrary graph and $K$ a field.

- The Leavitt path algebra $L_K(E)$ is left (right) weakly regular if and only if the graph $E$ satisfies Condition (K), and
- $L_K(E)$ is left (right) self-injective if and only if the graph $E$ is row-finite, acyclic and every infinite path contains a line point.

Along the way, we extend and prove several results on projective, injective and flat modules over Leavitt path algebras and, more generally, over not necessarily unital rings with local units. (Received August 31, 2009)

1056-16-412 **G. Alan Cannon**, **C. J. Maxson** and **Kent M. Neuerburg***, Southeastern Louisiana University, Department of Mathematics, SLU Box 10687, Hammond, LA 70402. *Rings and Covered Groups.* Preliminary report.

Let $\langle G, + \rangle$ be a group written additively, but not necessarily abelian, with identity element 0, and let $\mathcal{C} := \{A_1, A_2, \cdots, A_n\}$ be a cover of $G$ by abelian subgroups, i.e., each $A_i$ is an abelian subgroup of $G$ and $\cup_{i=1}^{n} A_i = G$. Let $\mathcal{R}(\mathcal{C}) := \{f : G \to G \mid f_{|A_i} \in \mathrm{End}(A_i)$ for all $i = 1, 2, \ldots, n\}$. We call $\mathcal{R}(\mathcal{C})$ the *ring determined by the cover* $\mathcal{C}$, where the operations are pointwise addition and function composition. We will discuss characterizations of $\mathcal{R}(\mathcal{C})$ given specific classes of covers $\mathcal{C}$. (Received September 04, 2009)

1056-16-520 **Paul Frank Baum*** (baum@math.psu.edu), Mathematics Department, Pennsylvania State University, University Park, PA 16802. *Morita Equivalence Revisited.*

MORITA EQUIVALENCE REVISITED

k denotes the coordinate algebra of a complex affine variety. A k-algebra is an algebra A over the complex numbers which is a k-module such that the algebra structure and the k-module structure are compatible in the evident way. Note that A is not required to be commutative. Prim(A) denotes the set of primitive ideals in A. Prim(A) is topologized by the Jacobson topology. This talk studies an equivalence relation between k-algebras which is a weakening of Morita equivalence. If A and B are equivalent in the new equivalence relation, then A and B have isomorphic periodic cyclic homology, and Prim(A) is in bijection with Prim(B). However, the bijection between Prim(A) and Prim(B) might not be a homeomorphism. Thus the new equivalence relation permits a tearing apart of strata in the primitive ideal spaces which is not allowed by Morita equvalence. An application to the representation theory of reductive p-adic groups will be outlined.

The above is joint work with A.M.Aubert and R.J.Plymen. (Received September 11, 2009)

1056-16-598 **Joerg Feldvoss** and **Sarah Witherspoon*** (sjw@math.tamu.edu). *Support varieties and representation type.*

Support varieties are useful invariants of modules that are defined homologically under some finiteness conditions. These varieties can provide information about the representation type of a finite dimensional algebra. We will first give an overview of this theory. Then we will explain how it leads to a wildness criterion for small quantum groups and more generally for finite dimensional Hopf algebras having finitely generated cohomology. (Received September 14, 2009)

1056-16-787 **Pere Ara*** (para@mat.uab.cat), Departament de Matematiques, Edifici C, Universitat Autonoma de Barcelona, 08193 Bellaterra, Barcelona, Spain, and **Kenneth R. Goodearl** (goodearl@math.ucsb.edu), Department of Mathematics, University of California, Santa Barbara, CA 93106. *Leavitt path algebras and graph C*-algebras of separated graphs, I.* Preliminary report.

A *separated graph* $(E, C)$ is a pair consisting of a directed graph $E$ and a family $C$ that gives partitions of the set of edges departing from each vertex of $E$. In joint work with K.R. Goodearl, we have introduced and investigated several algebras and C*-algebras associated to a separated graph $(E, C)$. I will recall the main definitions and give several interesting examples. One of these examples is closely related to the Leavitt algebras $L(m, n)$ with $1 \leq m \leq n$. (Received September 17, 2009)

1056-16-828 **P. Ara** and **K.R. Goodearl***, Department of Mathematics, University of California, Santa Barbara, CA 93106. *Leavitt path algebras and graph C*-algebras of separated graphs, II.* Preliminary report.

This talk will continue the discussion of algebras related to *separated graphs* $(E, C)$, which will be introduced in Pere Ara's talk. Some properties of these algebras, and the dependence of these properties on both $E$ and $C$, will be discussed. In particular, unlike the situation for ordinary Leavitt path algebras, the monoid of isomorphism classes of finitely generated projective modules over one of these new algebras is not always a refinement monoid. Conditions under which refinement holds will be presented. (Received September 17, 2009)

1056-16-857 **Aaron D Lauda*** (lauda@math.columbia.edu), Department of Mathematics, 2990 Broadway, New York, NY 10027. *Categorifying quantum groups.*

I will explain joint work with Mikhail Khovanov on a categorification of the quantum deformation of the "lower-triangular" subalgebra of a symmetrizable Kac-Moody algebra. This categorification is defined using categories of graded modules over an algebra that is diagrammatically defined using a graphical calculus. I will also survey some recent results and applications of these algebras. (Received September 18, 2009)

1056-16-866 **Chris Smith*** (cdsmith@gmail.com), 1420 Austin Bluffs Parkway, Colorado Springs, CO 80918, and **Gene Abrams** (abrams@math.uccs.edu), 1420 Austin Bluffs Parkway, Colorado Springs, CO 80918. *Explicit isomorphisms of purely infinite simple Leavitt path algebras.* Preliminary report.

The Kirchberg-Phillips theorem completely classifies purely infinite simple unital Cuntz-Kreiger graph $C^*$-algebras via $K$-theory, but does not describe the resulting isomorphisms explicitly. The classification of the purely algebraic Leavitt path algebras is as yet incomplete, but the explicit isomorphisms given in that classification extend to graph $C^*$-algebras as well. For example, isomorphisms between Leavitt algebras $L_n$ and their matrix rings also yielded the first explicitly described isomorphisms between the Cuntz algebras $\mathcal{O}_n$ and their matrix rings.

Recent work of the authors with Adel Louly and Enrique Pardo has achieved an algebraic analogue of the Kirchberg-Phillips theorem, classifying nearly all purely infinite simple unital Leavitt path algebras. We show that the resulting isomorphisms can be explicitly described, and the authors have implemented computer software to do so. As a result, nearly all isomorphisms implied by the Kirchberg-Phillips theorem for purely infinite simple unital graph $C^*$-algebras can be explicitly described as well. We also discuss the properties of these isomorphisms, and the obstacle to extending the classification result to all purely infinite simple unital Leavitt path algebras. (Received September 18, 2009)

1056-16-927 **Vera Serganova*** (serganov@math.berkeley.edu), Department of Mathematics, UC Berkeley, Berkeley, CA 94720. *Associated variety of simple finite-dimensional modules over classical Lie superalgebras and Kac-Wakimoto conjecture.* Preliminary report.

In 1994 V. Kac and M. Wakimoto introduced the notion of degree of atypicality of a highest weight module for a Kac-Moody superalgebra. They conjectured that a finite-dimensional simple module has a non-zero superdimension iff its degree of atypicality is maximal possible.

In 2003 M. Duflo and myself defined the associated variety for a finite-dimensional module over a finite-dimensional Lie superalgebras and conjectured that the associated variety of a simple module depends only on its degree of atypicality.

In this talk I present a proof of both conjectures for classical Lie superalgebras. The proof is based on a generalization of Borel-Weil-Bott theorem for supergroups. (Received September 18, 2009)

1056-16-943 **Gene Abrams*** (abrams@math.uccs.edu), Department of Mathematics, University of Colorado, Colorado Springs, CO 80918, and **Mark Tomforde**. *Isomorphism and Morita equivalence of graph algebras II.* Preliminary report.

In this talk we continue the discussion of various relationships between the Leavitt path algebra $L_{\mathbb{C}}(E)$ and graph C*-algebra $C^*(E)$ begun in Mark Tomforde's talk. In addition to furthering the description of situations in which ring isomorphisms between $L_{\mathbb{C}}(E)$ and $L_{\mathbb{C}}(F)$ yield $*$-algebra isomorphisms between $C^*(E)$ and $C^*(F)$, we present specific cases for which we get the reverse implication as well. The Kirchberg Phillips classification theorem, along with corresponding cases of its algebraic counterpart, play an important role here. Similar relationships in the context of Morita equivalences will also be described.

In the final portion of the talk we will present a number of perhaps surprising, still-not-completely-understood results of the form: $L_{\mathbb{C}}(E)$ satisfies ring-theoretic property $\mathcal{P}$ if and only if $C^*(E)$ satisfies ring-theoretic property $\mathcal{P}$ if and only if $C^*(E)$ satisfies the appropriate analytic property analogous to $\mathcal{P}$. (Received September 18, 2009)

1056-16-998 **Feng Chen*** (fchen@emory.edu), 400 Dowman Dr, Math and CS Dept. ,Suite N410, Atlanta, GA 30322. *Indecomposable division algebras over funtion fields of smooth p-adic curves.*

We construct indecomposable division algebras over function fields of smooth curves $X$ over $\mathcal{Z}_p$. This is done by defining a morphism $s : \mathrm{Br}(\hat{K}(X))' \to \mathrm{Br}(K(X))$, where $K(X)$ is the completion of $K(X)$ at the special fibre, and using it to lift indecomposable division algebras over $\hat{K}(X)$. (Received September 19, 2009)

1056-16-1023 **Mercedes Siles Molina*** (msilesm@uma.es), Dpto. de Algebra, Geometria y Topologia, Campus de Teatinos, Universidad de Malaga, 29071 Malaga, Malaga, Spain. *The role of the socle in the classification of Leavitt path algebras.*

The aim of this talk is to show a picture of how much is known about the classification of Leavitt path algebras, centering our attention in the socle. The second part of the talk will be devoted to the description of the socle series of a Leavitt path algebra. (Received September 20, 2009)

1056-16-1103 **Ted Chinburg*** (ted@math.upenn.edu), Department of Mathematics, University of Pennsylvania, Philadelphia, PA 19104, **Lourdes Juan** (lourdes.juan@ttu.edu), Department of Mathematics, Texas Tech University, Box 1042, Lubbock, TX 79409-1042, and **Andy Magid** (amagid@ou.edu), Department of Mathematics, University of Oklahoma, Norman, OK. *Analogies between differential Galois theory and additive Galois structure theory.* Preliminary report.

This talk will be about some results in differential Galois theory inspired by results in additive Galois module structure theory. The invariants we study have to do with refined information about the structure of Picard Vessiot rings as comodules for the Hopf algebra of the associated differential Galois group. (Received September 22, 2009)

1056-16-1106 **Jennifer Firkins Nordstrom*** (jfirkins@linfield.edu), Department of Mathematics A468, Linfield College, 900 S Baker Street, McMinnville, OR 97128. *Leavitt Path Algebras with Coefficients in a Noncommutative Ring.*

Given a directed graph $E$ we define a method for constructing a Leavitt path algebra $L_R(E)$ whose coefficients are in an arbitrary unital ring. We extend Tomford's work on Leavitt path algebras with coefficients in a commutative unital ring to the context of Leavitt path algebras with coefficients in a noncommutative ring. In particular, we extend Tomford's proofs of the Graded Uniqueness Theorem and the Cuntz-Krieger Uniqueness Theorem to Leavitt path algebras with coefficients in an arbitrary unital ring. Furthermore, we show that if $K$ is a field and $R$ is a $K$-algebra, then $L_R(E) \cong R \otimes L_K(E)$ as $R$-algebras. (Received September 20, 2009)

1056-16-1344 **Daniel Joseph Wackwitz*** (wackwidj@uwec.edu), 510D Chancellor's Hall, 820 University Drive, Eau Claire, WI 54701, and **Michael Robert Penkava**. *Moduli spaces of low dimensional associative algebras and their deformations.*

The speaker has been studying low dimensional algebras, including $Z_2$-graded algebras, as an undergraduate researcher. In this talk, I will discuss how we use the ideas of extensions of algebras by algebras, and the fundamental theorem of finite dimensional algebras, to construct the moduli space of algebras of a certain dimension using a classification of the nilpotent algebras and simple algebras of smaller dimension. This method uses a classification of $Z_2$-graded division algebras which we have obtained in some research last year. Then I will talk about how the deformations of these algebras, in particular, the versal deformations of an algebra, give a decomposition of the moduli space into families, which at least in the examples we have studied, are unique. These families give a stratification of the moduli space by very simple orbifolds. These strata are connected by deformations which factor through jump deformations. I will show how the versal deformations can be computed using some Maple worksheets which have been developed by the professor I am working with and some of his students, including myself. (Received September 21, 2009)

1056-16-1353 **Linhong Wang*** (lwang@selu.edu), Department of Mathematics, Southeastern Louisiana University, SLU 10687, Hammond, LA 70401. *On skew power series rings.* Preliminary report.

Skew power series rings over suitable base rings give new examples of local, noetherian, zariskian (in the sense of Li and Van Oystaeyen) domains, and can be considered as completions of corresponding skew polynomial rings. In this talk, I will be discussing results and open questions on skew power series rings, including recent joint work with E. S. Letzter. (Received September 22, 2009)

1056-16-1369 **Forest Fisher*** (fdfisher@gwmail.gwu.edu) and **William Schmitt** (wschmitt@gwu.edu). *A decomposition of the Dynkin idempotent in the Hopf algebra of graphs.* Preliminary report.

We define a graded, connected, cocommutative Hopf algebra with basis indexed by a family of graphs, and show that its coproduct splits into the sum of two (noncoassociative) coproducts. This allows us to define a sequence of maps $\alpha_1, \alpha_2, \ldots$, each of which maps into the primitives, and whose sum is the well-known Dynkin idempotent. In particular, the map $\alpha_1$ maps onto the primitive elements, and can be characterized in a familiar way by considering a different Hopf algebra grading. (Received September 21, 2009)

1056-16-1509 **Joshua Sussan*** (sussan@math.berkeley.edu), University of California Berkeley, 970 Evans Hall #3840, Berkeley, CA 94720. *Colored tangle invariants and quantum sl(2) categorification.*

We review the categorification of tensor products of the natural representation for quantum sl(2) and its extension to a tangle invariant. A categorification of tensor products of arbitrary finite dimensional, irreducible representations was given by Frenkel, Khovanov, and Stroppel. We show how to use these results to get a categorification of the colored Jones polynomial. This is joint work with Igor Frenkel and Catharina Stroppel. (Received September 22, 2009)

1056-16-1563 **Kathi Crow*** (kcrow@aucegypt.edu), Math Department, American University in Cairo, 420 Fifth Avenue, 3rd Floor, New York, NY 10018. *Unit-regular Skew Group Rings.*

A skew group ring $R * G$ can be formed whenever we have a group $G$ acting on a ring $R$. When considering this construction, it is only natural to ask what properties of $R$ carry over to $R * G$. In this talk we will provide examples that are well-known, such as conditions for $R * G$ to be von Neumann regular and then we will consider the question of when a skew group ring is unit-regular. (Received September 22, 2009)

1056-16-1656 **Jose A. Velez-Marulanda*** (jvelezma@math.uiowa.edu), University of Iowa, Department of Mathematics, 14 MLH, Iowa City, IA 52242. *A combinatorial approach to the description of endomorphism rings.* Preliminary report.

Quivers, which are directed graphs, play an important role in the representation theory of finite dimensional algebras. If $k$ is an algebraically closed field, then every finite dimensional $k$-algebra can be realized as a quotient algebra of the path algebra $kQ$ of a certain quiver $Q$. We concentrate on a specific quiver $Q$ in which each vertex is the starting point (respectively the end point) of exactly two arrows. We consider a particular quotient $\Lambda = kQ/I$ of the path algebra $kQ$ such that all finitely generated $\Lambda$-modules can be described combinatorially by using certain words in $\Lambda$, called strings and bands. We determine all the $\Lambda$-modules associated to strings whose stable endomorphsim ring is isomorphic to $k$. (Received September 22, 2009)

1056-16-1814 **Colleen Duffy*** (duffycm@uwec.edu), University of Wisconsin - Eau Claire, Department of Mathematics - Hibbard Hall, Eau Claire, WI 54701. *Action of the symmetry group of the $n$-dimensional hypercube on the algebra associated to the Hasse graph of the $n$-cube.* Preliminary report.

It is interesting to study the structure of (graded) algebras associated to directed graphs. There is an algebra $A(\Gamma_{\{4,3^{n-2}\}})$ associated to the directed Hasse graph $\Gamma_{\{4,3^{n-2}\}}$ of the $n$-dimensional hypercube. Let $E$ be the set of edges in the graph and let $P_\pi(t) = (1-te_1)\cdots(1-te_m)$ for any directed path $\pi = \{e_1, ..., e_m : e_i \in E\}$ in $\Gamma_{\{4,3^{n-2}\}}$. Then $A(\Gamma_{\{4,3^{n-2}\}})$ is the quotient of the free algebra $T(E)$ by the relations given by $P_{\pi_1}(t) = P_{\pi_2}(t)$ where $\pi_1$ and $\pi_2$ have the same initial and final vertices. The symmetry group of the $n$-dimensional hypercube, which is the Coxeter group $[4, 3^{n-2}]$, acts naturally on $\Gamma_{\{4,3^{n-2}\}}$, and so on each of the homogeneous subspaces $A(\Gamma_{\{4,3^{n-2}\}})_{[i]}$ of $A(\Gamma_{\{4,3^{n-2}\}})$. For each element $(\sigma,\vec{a})$ in the Coxeter group, we find the graded trace function $\mathrm{Tr}_{(\sigma,\vec{a})} = \sum_{i\geq 0} \mathrm{Tr}_{(\sigma,\vec{a})}|_{A(\Gamma_{\{4,3^{n-2}\}})_{[i]}} t^i$. We use these graded trace generating functions to obtain the multiplicities of the irreducible $[4, 3^{n-2}]$-modules in $A(\Gamma_{\{4,3^{n-2}\}})_{[i]}$. (Received September 22, 2009)

# 17 ► Nonassociative rings and algebras

1056-17-120 **Nora C. Hopkins*** (Nora.Hopkins@indstate.edu), Dept. of Math. and Comp. Sci., Indiana State University, Terre Haute, IN 47809. *Periodicity of quadratic differential equations in nonassociative algebras and dimensions of subalgebras.*

Suppose $A$ is a finite dimensional commutative non-associative algebra over the reals. It has long been known that $Z(t,P) \in A(P)$ for all $t$ in the domain of $Z(t,P)$ where $Z(t,P)$ is the solution to the vector differential equation $\frac{dZ}{dt} = Z^2$ with $Z(0,P) = P$, and $A(P)$ is the sub-algebra of $A$ generated by $P$. This is still true if all of the variables are complexified. For any algebra generated by $Q$ in $A + iA$. Using Galois cohomology, I will show that if $P \in A, Q = Z(t_0,P)$ for some $t_0 \notin \mathbb{R}$, $\dim_{\mathbb{C}} Q = \dim_{\mathbb{C}} P$, the domain of $Z(t,P)$ is $\mathbb{C}$, and $Aut\,A(P)$ is a finite group, then $Z(t,P)$ is periodic with a non-real period. (Received July 28, 2009)

1056-17-181 **Audrey Malagon*** (malagon_al@mercer.edu), Dept. of Mathematics, Mercer University, 1400 Coleman Ave., Macon, GA 31207. *Killing Forms of Isotropic Lie Algebras.*

This paper presents a method for computing the Killing form of an isotropic Lie algebra defined over an arbitrary field based on the Killing form of a subalgebra containing its anisotropic kernel. This approach allows for streamlined formulas for many exceptional Lie algebras of inner and outer type $E_6$ and type $E_7$ and yields a unified formula for all Lie algebras of inner type $E_6$, including the anisotropic ones. (Received August 12, 2009)

1056-17-183 **Julie C Beier*** (beier_jc@mercer.edu), Mercer University, Department of Mathematics, 1400 Coleman Avenue, Macon, GA 31207. *On Demazure Crystals of $U_q(\widehat{sl}(n))$.*

Crystal bases provide a useful tool for studying the combinatorics of integrable representations of quantum affine algebras. The integrable modules contain certain important subspaces called Demazure modules. Here we look specifically at the quantum affine algebra $U_q(\widehat{sl}(n))$. The crystal bases for integrable modules of the quantum affine algebra can be realized in terms of combinatorial objects called extended Young diagrams. We utilize this realization and the definition of Demazure crystals to give concrete realizations of a certain family of Demazure modules for the quantum affine algebra $U_q(\widehat{sl}(n))$ in terms of these extended Young diagrams. In addition we give some formulas for calculating the weights of extremal elements in these modules. (Received August 12, 2009)

1056-17-229 **Murray R Bremner*** (bremner@math.usask.ca), Department of Mathematics and Statistics, University of Saskatchewan, Saskatoon, SK S7N 5E6, Canada, and **Luiz A Peresi**. *Special identities for quasi-Jordan algebras.*

Velasquez and Felipe defined a (right) quasi-Jordan algebra to be a nonassociative algebra satisfying right commutativity $a(bc) = a(cb)$ and the right quasi-Jordan identity $(ba)a^2 = (ba^2)a$. These identities are satisfied by the product $ab = \frac{1}{2}(a \dashv b + b \vdash a)$ in an associative dialgebra with operations $\dashv$ and $\vdash$ over a field of characteristic $\neq 2, 3$. This product also satisfies the associator-derivation identity $(b, a^2, c) = 2(b, a, c)a$. We use computer algebra and the representation theory of the symmetric group to show that there are no new identities for this product in degree $\leq 7$, but that six new irreducible identities exist in degree 8. These new identities are quasi-Jordan analogues of the Glennie identities for special Jordan algebras. (Received August 17, 2009)

1056-17-238 **Nathan Geer**, Dept. of Mathematics, Utah State University, Logan, UT 84322, **Jonathan Kujawa***, Dept. of Mathematics, University of Oklahoma, Norman, OK 73019, and **Bertrand Patureau-Mirand**, Dept. of Mathematics, Université de Bretagne-Sud, Vann, France. *Generalized Trace and Dimension Functions in Ribbon Categories.*

Ribbon categories are ubiquitous in representation theory. They appear as the finite dimensional representations of groups, Lie (super)algebras, and quantum (super)groups. An essential tool in studying these categories is the trace of an endomorphism and the dimension of object. Using low dimensional topology we generalize these notions and prove that these functions provide new insights into representation theory. (Received August 18, 2009)

1056-17-245 **Kenyon J Platt*** (platt@math.byu.edu), 310 TMCB, Department of Mathematics, Brigham Young University, Provo, UT 84602, and **Bobbe J Cooper**. *Nilpotent Orbit Theory and Infinitesimal Blocks of Parabolic Category $\mathcal{O}$.* Preliminary report.

Let $\mathfrak{g}$ be a simple Lie algebra over the complex numbers. Parabolic category $\mathcal{O}_S$ is a generalization of the usual BGG category $\mathcal{O}$. This category of $\mathfrak{g}$-modules decomposes into certain subcategories, called infinitesimal blocks, which have some nice properties. For example, each block has at most finitely many simple modules. In fact, some contain no simple modules at all. We will discuss a relationship between the nilpotent orbits of $\mathfrak{g}$ and the extensions between simple modules in a given infinitesimal block of category $\mathcal{O}_S$. (Received August 19, 2009)

1056-17-363 **Kristen Stagg*** (klstagg@ncsu.edu), 3300 Walnut Creek Pkwy Apt. F, Raleigh, NC 27606. *Properties of the Frattini Subalgebra in a Lie algebra.* Preliminary report.

For any Lie algebra $L$, the Frattini subalgebra $F(L)$ is the intersection of all maximal subalgebras of $L$. Properties of the Frattini subalgebra have been investigated by a number of authors. We will discuss concepts which evolve when considering the Frattini subalgebra and its properties. Many of the discussed concepts have analogues in group theory. (Received September 02, 2009)

1056-17-364 **Lindsey R Bosko*** (lrbosko@ncsu.edu), 4006 The Oaks Dr, Raleigh, NC 27606. *Multipliers of Lie Algebras of Maximal Class.* Preliminary report.

For a nilpotent Lie algebra, $L$ of dimension $n$ with multiplier $M(L)$ define $t(L) = \frac{1}{2}n(n-1) - \dim M(L)$. The classification of all such Lie algebras for which $t(L) \leq 8$ is known, but by requiring $L$ to be of maximal class, we can characterize $L$ for cases in which $t(L) > 8$. In this talk we discuss how this classification led to a proposition which bounds $t(L)$ as well as the group theory analogue of the proposition, which has been proven for nilpotent $p$-groups of maximal class. (Received September 02, 2009)

1056-17-415 **Erhard Neher** and **Alistair Savage*** (alistair.savage@uottawa.ca), Department of Mathematics, University of Ottawa, Ottawa, Ontario K1N 6N5, and **Prasad Senesi**. *Equivariant map algebras.*

Suppose a finite group acts on a scheme (or algebraic variety) $X$ and a finite-dimensional Lie algebra $\mathfrak{g}$. Then the space of equivariant algebraic maps from $X$ to $\mathfrak{g}$ is a Lie algebra under pointwise multiplication. Examples of such equivariant map algebras include (multi)current algebras, (multi)loop algebras, three point Lie algebras, and the (generalized) Onsager algebra. In this talk we will present a classification of the irreducible finite-dimensional representations of an arbitrary equivariant map algebra. It turns out that (almost) all irreducible finite-dimensional representations are evaluation representations. As a corollary, we recover known results on the representation theory of particular equivariant map algebras (for instance, the loop algebras and the Onsager algebra) as well as previously unknown classifications of other equivariant map algebras (for example, the generalized Onsager algebra). All such classifications are specializations of the general theorem. (Received September 15, 2009)

1056-17-464 **Alexander Kleshchev*** (klesh@uoregon.edu), Department of Mathematics, University of Oregon, Eugene, OR 97403, and **Arun Ram**, Department of Mathematics and Statistics, The University of Melbourne, Parkville, VIC 3010, Australia. *Representations of Khovanov-Lauda-Rouquier algebras and combinatorics of Lyndon words.*

We construct irreducible representations of affine Khovanov-Lauda-Rouquier algebras of arbitrary finite type. The irreducible representations arise as simple heads of appropriate induced modules, and thus our construction is similar to that of Bernstein and Zelevinsky for affine Hecke algebras of type $A$. The highest weights of irreducible modules are given by the so-called good words, and the highest weights of the 'cuspidal modules' are given by the good Lyndon words. In a sense, this has been predicted by Leclerc. (Received September 08, 2009)

1056-17-489 **Alicia Labra*** (alimat@uchile.cl), Departamento de Matematicas, Facultad de Ciencias, Univ. de Chile, Casilla 653, Santiago, Chile. *Locally Nilpotency in Commutative Right Nilalgebras.*

This talk is based in two joint works with I. Correa and I. R. Hentzel[2] and the second with A. Behn and A. Elduque[1]. It deals with the variety of commutative non associative algebras satisfying LxLxLx + tL(xx)x = 0, t in K. In [2] it is proved that if t = 0,1 then any finitelly generated algebra is nilpotent. In [1] we generalize this result by proving that if t is not -1, the any such algebra is locally nilpotent. Our results require characteristic not 2,3.

[1] A. Behn, A. Elduque, A. Labra, On a class of Locally Nilpotent Commutative Algebras, sumitted July, 2009.

[2] I. Correa, I. R. Hentzel, A. Labra, Nilpotency of Commutative Finitely Generated Algebras satisfying LxLxLx + tL(xx)x = 0, t = 0,1. To appear in Journal of Algebra. (Received September 09, 2009)

1056-17-665 **Charles H Conley*** (conley@unt.edu), Department of Mathematics, 1155 Union Circle #311430, University of North Texas, Denton, TX 76203-5017. *Quantizations of differential operator modules.*

Suppose that one has an infinite dimensional Lie algebra of vector fields on a manifold, for example the set of all vector fields, or, if the manifold has a contact structure, the contact vector fields. Assume that this Lie algebra contains a distinguished finite dimensional semisimple maximal subalgebra, usually called its projective or conformal subalgebra.

There are various spaces of differential operators on the manifold which carry natural representations of such Lie algebras. The projective or conformal quantization of such a representation is its decomposition into irreducible representations of the subalgebra. We discuss recent results on quantizations and their applications to cohomology, geometric equivalences and symmetries of differential operator modules, and indecomposable modules. Our methods are algebraic: we consider only Euclidean manifolds. (Received September 15, 2009)

1056-17-672 **Raul Felipe***, CIMAT, Jalisco S/N, Valenciana, 36240 Guanajuato, Mexico. *The quasi-jordan algebras.* Preliminary report.

In certain sense the quasi-Jordan algebras are the Jordan analogs for Leibniz algebras. In this talk I will report a part of my recent work on quasi-jordan algebras and some related structures from which can be constructed. (Received September 15, 2009)

1056-17-718 **Marina Tvalavadze*** (marina@math.usask.ca), University of Saskatchewan, Department of Mathematics and Statistics, Saskatoon, SK S7N5E6, Canada. *Enveloping algebras of Malcev algebras.*

By definition, a Malcev algebra is a vector space $M$ over a field with a bilinear product $[a, b]$ satisfying anticommutativity and the Malcev identity:

$$[J(a, b, c), a] = J(a, b, [a, c])$$

where $J(\cdot\,, \cdot\,, \cdot)$ is the Jacobian. In 2004, Perez-Izquierdo and Shestakov constructed the universal non-associative enveloping algebra $U(M)$ for a Malcev algebra $M$. Although this enveloping algebra is not generally alternative, it has a PBW-basis and shares many properties of a universal enveloping algebra of a Lie algebra. This resulted in an extensive studying of enveloping algebras of Malcev algebras of various types. For 4-dimensional solvable Malcev algebra and 5-dimensional nilpotent Malcev algebra the structural constants of their enveloping algebras have been found by M. Bremner, I. Hentzel, A. Peresi, H. Usefi. According to Kuzmin's classification, there are also 5-dimensional non-solvable Malcev algebra and 5-dimensional solvable Malcev algebras of five different types. It is a work in progress to determine the structural constants of 5-dimensional non-solvable Malcev algebra. In this talk we will look into the case of 5-dimensional solvable Malcev algebras, discuss the properties of their enveloping algebras. (Received September 16, 2009)

1056-17-801 **Kenneth L Price*** (pricek@uwosh.edu), Mathematics Department, University of Wisconsin Oshkosh, 800 Algoma Boulevard, Oshkosh, WI 54901, and **Stephen Szydlik** (szydliks@uwosh.edu), Mathematics Department, University of Wisconsin Oshkosh, 800 Algoma Boulevard, Oshkosh, WI 54901. *Blocked and Group-Graded Matrix Constructions from Directed Graphs.* Preliminary report.

We describe a basis theory on the edge set of a directed graph. This is used to study homomorphisms from directed graphs to groups and provides the foundation for constructing group-graded matrix algebras composed of blocks associated to components of directed graphs. Our results are related to an earlier construction of A. V. Kelarev for blocked matrix Lie superalgebras. (Received September 17, 2009)

1056-17-1130 **Cristina Draper*** (cdf@uma.es), Escuela de Las Ingenierías, Dpto. Matemática Aplicada, Universidad de Málaga (Ampliación Teatinos), 29071 Málaga, Spain, and **Alberto Elduque** and **Cándido Martín**. *Gradings on exceptional Lie superalgebras.*

We determine all the fine group gradings on the classical exceptional Lie superalgebras $G(3)$, $F(4)$ and the family $D(2,1;\alpha)$. The main tool is the knowledge of the automorphism groups of such superalgebras [1].

In order to provide nice descriptions of these gradings, we make use of different models of our Lie superalgebras, thus relating their gradings to gradings on some other nonassociative algebras: the Lie algebra $\mathfrak{sl}_2$, the Jordan superalgebras $K_{10}$ (Kac's superalgebra) and $D_\alpha$'s, and the octonion algebra.

Our work extends previous results in [2], which deals with group gradings of the orthosymplectic Lie superalgebras, and it complements the recent work by a number of authors on gradings on simple Lie and Jordan algebras.

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[2] Tvalavadze, M.; Tvalavadze, T. *Group gradings on superalgebras*. Arxiv: 0609760v2. (Received September 21, 2009)

1056-17-1147 **Pilar Benito*** (pilar.benito@unirioja.es), Departamento de Matemáticas y Computación, Edificio Vives, Luis de Ulloa s/n, 26004 Logroño, La Rioja, Spain. *Lie-Yamaguti algebras and related structures.* Preliminary report.

Lie-Yamaguti algebras (LY-algebra for short) are nonassociative binary-ternary algebraic systems introduced in 1957 by K. Yamaguti in connection with reductive homogeneous spaces. The LY-algebras with binary trivial product are the so call Lie triple systems, while the LY-algebras with trivial ternary product are exactly the Lie algebras. Less known examples of LY-algebras arising from homogeneous spaces related to the compact Lie group $G_2$ where described by Benito-Draper-Elduque in 2005.

The LY-algebras which are irreducible as modules over their Lie inner derivation algebra are the goal in this talk. They are the algebraic counterpart of the isotropy irreducible homogeneous spaces classify by J. A. Wolf in 1968. These irreducible systems splits into three disjoint types: adjoint type, non-simple type and generic type. We shall show that certain nonassociative systems like Lie and Jordan algebras, symplectic and orthogonal triples and Jordan pairs can be used to classify these three different types of LY-algebras. This is a joint work with Alberto Elduque and Fabián Martín-Herce. (Received September 21, 2009)

1056-17-1172 **Murray Bremner**, **Ivan Correa** and **Irvin Hentzel*** (hentzel@iastate.edu), Dept. of Mathematics, Ames, IA 50011-2064, and **Luiz Peresi**. *Special Bol Identities.* Preliminary report.

A Bol algebra is defined in terms of a binary product [a,b] and a ternary product <a,b,c>. These five identities are assumed to hold.

[a,b]+[b,a] = 0

<a,b,c>+<b,a,c> = 0

<a,b,c>+<b,c,a>+<c,a,b> = 0

<a,b,<c,d,e>> − <<a,b,c>,d,e> - <c,<a,b,d>,e> - <c,d,<a,b,e>>= 0

[<a,b,c>,d]-[<a,b,d>,c]+<c,d,[a,b]>-<a,b,[c,d]>+[[a,b],[c,d]] = 0

The Special Bol algebra starts with a right alternative algebra and defines [a,b] = ab-ba and <a,b,c> = J(b,c,a) = (boc)oa-bo(coa) where xoy = xy+yx is the symmetric product in the right alternative algebra and J(b,c,a) is the associator computed using the symmetric product.

There are 13 minimal identities that hold in the Special Bol algebra that do not hold in the free bol algebra. They are distributed across 6 representations as follows: 1 in (62); 4 in (53); 1 in (521); 2 in (44); 4 in (431); 1 in (3311); One of the two identities in tableau (44) is expressible with 73 terms. We are still working on methods to express the other identities by hundreds of terms rather than by thousands of terms. (Received September 21, 2009)

1056-17-1224 **Tevian Dray*** (tevian@math.oregonstate.edu), Department of Mathematics, Oregon State University, Corvallis, OR 97330, and **Aaron Wangberg** (awangberg@winona.edu), Department of Mathematics, Winona State University, Winona, MN 55987. *The Structure of $E_6$.*

We discuss the subalgebra structure of $sl(3, \mathbb{O})$, a particular real form of $E_6$ chosen for its relevance to particle physics [1]. We use an explicit octonionic representation of the Lie group $SL(3, \mathbb{O})$ to produce the multiplication table of the corresponding algebra. We identify various subalgebras of the form $sl(n, \mathbb{F})$ and $su(n, \mathbb{F})$ within $sl(3, \mathbb{O})$, and we also find algebras corresponding to generalized Lorentz groups. We identify six Casimir operators in $sl(3, \mathbb{O})$, and produce a nested sequence of subalgebras and Casimir operators containing not only $su(3) \oplus su(2) \oplus u(1)$, corresponding to the Standard Model of particle physics, but also $so(3, 1)$, corresponding to the Lorentz group of special relativity.

(1) Aaron Wangberg, *The Strucure of $E_6$*, Ph.D. dissertation, Department of Mathematics, Oregon State University, 2007; available at http://arxiv.org/abs/0711.3447.

(Received September 21, 2009)

1056-17-1333 **Mikhail V Kotchetov*** (mikhail@mun.ca), Department of Mathematics and Statistics, Memorial University of Newfoundland, St. John's, NL A1C 5S7, Canada. *Group gradings on Lie algebras in positive characteristic.*

We are interested in describing all group gradings on simple Lie algebras over an algebraically closed field $F$, i.e., all vector space decompositions of the form $L = \bigoplus_{g \in G} L_g$ where $L$ is a simple Lie algebra, $G$ is a group, and $[L_g, L_h] \subset L_{gh}$. In the case char$F = 0$, all gradings on the simple Lie algebras of the series $A$, $B$, $C$ and $D$ have been classified. Essentially the same classification is valid for these Lie algebras in the case char$F = p > 2$. In this talk we will discuss recent progress in the classification of gradings on simple Lie algebras of Cartan type in characteristic $p$.

This is a joint work with Y. Bahturin and J. McGraw. (Received September 21, 2009)

1056-17-1394 **Arkady Berenstein**, Department of Mathematics, University of Oregon, Eugene, OR 97403, and **Jacob Greenstein***, Department of Mathematics, University of California Riverside, 900 University avenue, Riverside, CA 92521. *On quantum foldings.* Preliminary report.

A classical result in Lie theory stipulates that every finite dimensional simple Lie algebra $\mathfrak{g}$ which is not of type ADE can be constructed as the fixed point subalgebra for a diagram automorphism $\sigma$ of a simple Lie algebra $\mathfrak{s}$ of type ADE. This construction does not have a direct quantum analogue. The aim of the present talk is to explain how to construct a homomorphism of associative algebras from a subalgebra in the algebra of fixed points for $\sigma$ of the upper triangular part of $U_q(\mathfrak{s})$ onto the quantized enveloping algebra of the upper triangular part of $U_q(\mathfrak{g}^\vee)$, where $\mathfrak{g}^\vee$ is the Langlands dual of $\mathfrak{g}$. (Received September 21, 2009)

1056-17-1729 **Louis A. Levy*** (Louis.Levy@millersville.edu), Department of Mathematics, Millersville University, P.O. Box 1002, Millersville, PA 17551-0302. *Multipliers for the Nilpotent Series of Strictly Upper Triangular Matrices.* Preliminary report.

A Lie algebra multiplier is the Lie algebra analogue of group theory's Schur multiplier. Multipliers and their properties in the Lie algebra setting is a recent area of study. By definition a multiplier is central, so the primary focus for classifying them is computing their dimensions. In this talk we will study the techniques necessary for computing the dimensions of every Lie algebra in the lower central series of strictly upper triangular matrices. The closed form result is a set of six polynomial answers in two variables: the size of the matrices and the position in the series. (Received September 22, 2009)

# 18 ► Category theory; homological algebra

1056-18-316 **Deepak Naidu*** (dnaidu@math.tamu.edu), Department of Mathematics, Texas A&M Univesity, 3368 TAMU, College Station, TX 77843, and **Eric Rowell**. *A finiteness property for braided fusion categories.*

We consider the following question: Is it true that braid group representations associated with a braided fusion category have finite image if, and only if, the FP-dimension of the category is an integer? We will discuss some empirical evidence that supports an affirmative answer to the above question (arXiv:0903.4157v3). (Received August 28, 2009)

1056-18-983 **Jonny Comes*** (jcomes@uoregon.edu). *Blocks in Deligne's $Rep(S_t)$.*

Recently Deligne introduced the tensor category $Rep(S_t)$ where $t$ is not necessarily an integer. When $t$ is not a nonnegative integer, $Rep(S_t)$ is a semisimple category. When $t$ is a nonnegative integer, $Rep(S_t)$ is a non-semisimple category which "interpolates" representations of the symmetric group $S_t$. In this talk I will describe the blocks of $Rep(S_t)$ in the non-semisimple cases. (Received September 19, 2009)

1056-18-1036 **Leandro Marin*** (leandro@um.es), Departamento de Matematica Aplicada, Facultad de Informatica., Campus de Espinardo., 30071 Murcia, Murcia, Spain. *Leavitt Algebras and Categories of Modules for Nonunital Rings.* Preliminary report.

It will be presented the strong connections between the Leavitt algebras and nonunital rings, in particular it will be proved that the $k < X >$-modules that satisfy the Sato property are exactly the firm modules over some special nonunital rings. It will be presented also the structure of these categories of modules and their topological description. (Received September 20, 2009)

1056-18-1937 **C. Joanna Su*** (jsu@providence.edu), Dept. of Mathematics and Computer Science, Providence College, Providence, RI 02918. *The First of the Three Homotopy Exact Sequences of a Fibration in Module Theory.*

The homotopy theory of modules was developed by Peter Hilton in the 1950s. It produced an analog to the existing homotopy theory in algebraic topology. However, while the concept of a fiber map in module theory seemed natural and did induce an exact sequence, the 'expected' homotopy sequence - one that is parallel to and carries the same character as the homotopy exact sequence of a fibration in topology - failed to be discovered at the time. It turns out that, in module theory, a fibration induces not one, but three homotopy sequences. Based on the character of each individual, they are named as the first, the expected, and the automatic homotopy exact sequences of a fibration, respectively. In this talk we discuss the first sequence. The significance of this sequence varies from different viewpoints. It is of interest because of its virtually identical appearance to the homotopy exact sequence of a fibration from topology. On the other hand, the sequence is in some ways "deficient" because it misses the expected isomorphism between the relative homotopy group and the homotopy group of the base space, a special feature in topology. Nevertheless, it carries an interesting new feature, namely, the relative homotopy group is isomorphic to the homotopy group of the 'fiber'. (Received September 22, 2009)

# 19 ► K-theory

1056-19-559 **Semail ULGEN YILDIRIM*** (sulgen@math.northwestern.edu), 2033 Sheridan Rd, Lunt Hall 223, Evanston, IL 60208. *Tiling spaces and the Baum Connes Conjecture.* Preliminary report.

We recall the work on crossed product $C^*$-algebras such as the $C^*$-algebra $A = C(\Omega) \rtimes R^d$ where $R^d$ acts on $C(\Omega)$ by translations and the hull (tiling space) $\Omega$ is a compact space formed by translations of a given tiling $T$. J. Bellissard defined the notion of a hull $(\Omega, R^d, T)$ to model aperiodic solids. The hull is a dynamical system with group $R^d$ acting by homeomorphisms on a compact metrizable space. In the case of a perfect crystal, with translation group $G$, the hull is homeomorphic to the $d - dimensional$ torus $T^d$. With any dynamical system, there is a canonical $C^*$-algebra, namely the crossed product $C^*$-algebra $A = C(\Omega) \rtimes R^d$. We modify this algebra by enlarging the hull after including rotational symmetry in addition to translational symmetry on tiles, in particular on aperiodic tilings and call it the modified Bellissard Algebra. In the periodic case one can study the $K$-theory of this modified $C^*$-algebra and try to detect the type of the crystal. We briefly recall Baum-Connes Conjecture and mention the use of the proven results of this famous Baum Connes Conjecture. (Received September 12, 2009)

1056-19-647 **Timothy K Lance*** (TLance@fmarion.edu), Department of Mathematics, Leatherman 401, Francis Marion University, Florence, SC 29501. *Continuous Control in Exact Non-Split Categories.* Preliminary report.

Loday first introduced the assembly map for formulating the Novikov Conjecture in algebraic terms; showing that the assembly map is a split injection is equivalent to proving the conjecture. Later, Carlsson and Pedersen built on this work proving the conjecture in continuously and boundedly controlled $K$-theory for groups with "good" compactification. The classical $G$-theory assembly map, however, does not split in general. In this paper, I worked in the setting of $K$-theory with the appropriate exact non-split category which was constructed in the spirit of classical $G$-theory. I proved new controlled excision theorems which can be applied to the work of Carlsson and Pedersen to show the generalized assembly map is injective. This result is stronger than the previous results of Carlsson and Pedersen, justifying my use refined techniques developed in this paper. (Received September 15, 2009)

1056-19-1069 **Youngsoo Kim*** (ykim33@illinois.edu), University of Illinois at Urbana-Champaign, Department of Mathematics, 1409 W. Green Street, Urbana, IL 61801. *Motivic symmetric ring spectrum representing algebraic $K$-theory.*

Voevodsky showed that there is a motivic spectrum representing algebraic $K$-theory. An equivalent spectrum that is also a symmetric ring spectrum is constructed using Gillet-Grayson $K$-theory. A coherence problem occurs when one verifies the symmetry. It is solved by introducing the concept of standard vector bundles, which is a category of vector bundles with strictly associative tensor product that is also strictly commutative with line bundles. (Received September 22, 2009)

1056-19-1689 **Mu-wan Huang*** (mu-wan.huang@smsu.edu), Southwest Minnesota State University, 1501 State St., Marshall, MN 56258. *Fan Cohomology and Equivariant Chow Rings of Toric Varieties.*

We study the sheaf cohomology groups for the rational, completed equivariant $K$-groups, and how they relate to the equivariant $K$-groups of non-smooth and non-affine toric varieties. The rational, complete equivariant $K$-groups coincide with the equivariant Chow rings for affine toric varieties. For a three-dimensional complete fan, we calculate the dimensions of the sheaf cohomology groups for the symmetric algebra sheaf. When the fan is given by a convex polytope, this information computes the rational, complete equivariant $K$-groups as extensions of sheaf cohomology groups. (Received September 22, 2009)

# 20 ► Group theory and generalizations

1056-20-77 **Michelle Bowser*** (bowserml1@gcc.edu), Grove City College, Number 1780, 100 Campus Drive, Grove City, PA 16127, and **Trevor Partridge** and **Kirsten Rodgers**. *The Strong Symmetric Genus of Small D-type Generalized Symmetric Groups.* Preliminary report.

For each positive integers $m$ and $n$, the generalized symmetric group $G(n,m)$ is defined to be the group generated by all $n \times n$ permutation matrices and all $n \times n$ diagonal matrices with entries in the $m^{th}$ roots of unity. The D-type generalized symmetric group $D(n,m)$ is the normal subgroup of $G(n,m)$ generated by all $n \times n$ permutation matrices and all $n \times n$ diagonal matrices with entries in the $m^{th}$ roots of unity that have determinant 1. The strong symmetric genus of a finite group $G$ is the smallest genus of a closed orientable topological surface on which $G$ acts faithfully as a group of orientation preserving symmetries. We obtain the strong symmetric genus of each group $D(n,m)$ where $n = 3, 4,$ or 5. This project was supervised by Dr. Michael A. Jackson. (Received July 22, 2009)

1056-20-122 **Stephen M. Gagola, Jr.*** (gagola@math.kent.edu), Department of Mathematics, Kent State University, Kent, OH 44242. *Subgroups of $S_{n+1}$ normalized by and coprime to a regular subgroup of order $n$.* Preliminary report.

Let $H$ be a regular subgroup of the symmetric group $S_n$, and regard $S_n < S_{n+1}$ so that $H$ may be viewed as permuting $n+1$ points and having two orbits, one regular and one trivial. We determine conditions on $H$ so that $H$ normalizes a nontrivial subgroup $K < S_{n+1}$ of order coprime to that of $H$, and are interested in determining the number of such subgroups $K$.

As an example, if $n = p$ is a prime number, then $H$ must be cyclic and generated by a $p$-cycle. Furthermore, $p = 2^q - 1$ must be a Mersenne prime, and the number of subgroups $K$ of order not divisible by $p$ that are normalized by $H$ is $(2^q - 2)/q$. (Received July 28, 2009)

1056-20-130 **Stephen M Gagola III*** (sgagola@math.arizona.edu), Department of Mathematics, University of Arizona, 617 N. Santa Rita Ave, Tucson, AZ 85721. *On coverings of the smallest Paige loop.*

Here we use Zorn vector matrices, forming a split octonion algebra, to determine the covering number of the smallest Paige loop. It is known that no finite group has a covering number of seven. We prove that this is not true for Moufang loops showing that the smallest Paige loop has a covering number of seven. We also show that its automorphism group, $G_2(2)$, permutes these coverings transitively. (Received September 10, 2009)

1056-20-139 **Ming-Hsuan Kang*** (kang_m@math.psu.edu), 2302 Plaza Drive, State College, PA 16801. *Zeta Functions of Complexes Arising from $PGL_n$.*

In this talk, we define zeta functions on finite quotients of the Affine Bruhat-Tits building $B_n$ of $G$=PGL($n$) over a p-adic local field and discuss their properties.

Fix a finite quotient $X_\Gamma$ of $B_n$ by a discrete cocompact torsion-free subgroup $\Gamma$. $X$ is an $(n-1)$-dimensional CW complex and its simplices are parametrized by cosets of parahoric subgroups. We attach each standard parahoric subgroup $P$ a local zeta function, which counts the number of closed geodesic passing through the cosets of $P$. These local zeta functions are rational functions and have closed forms in terms of parahoric Hecke operators.

The main result is to show the twisted alternating product of these zeta functions satisfy an identity involving the Euler characteristic of $X_\Gamma$. The proof is based on the decomposition of $L^2(\Gamma\backslash G)$ and the classification of irreducible admissible representations of PGL($n$).

Moreover, we can use this twisted alternating product to test the triviality of continuous cohomology of a $G$-module.

Finally, we conjecture some equivalent conditions on Ramanujan property of $X_\Gamma$ via the absolute values of roots of these zeta functions. (Received July 31, 2009)

1056-20-272 **Arturo Magidin*** (magidin@member.ams.org), 217 Maxim Doucet Hall, P.O. Box 41010, Lafayette, LA 70504-1010. *The nilpotent product and the nonabelian tensor square of groups.* Preliminary report.

In 1956, Golovin defined nilpotent products of groups in response to a question of Mal'cev. If $A$ and $B$ are groups, the $c$-nilpotent product of $A$ and $B$ is defined to be $A \amalg^{\mathfrak{N}_c} B = (A*B)/((A*B)_{c+1} \cap [A,B])$, where $A*B$ is the free product and $(A*B)_{c+1}$ is the $(c+1)$st term of the lower central series of $A*B$; this is an associative product, and is generated by isomorphic copies of the factors. In 1960, T. MacHenry proved that the cartesian $[A,B]$ of $A \amalg^{\mathfrak{N}_2} B$ is isomorphic to the abelian tensor product $A^{\mathrm{ab}} \otimes B^{\mathrm{ab}}$. We discuss a possible generalization of this result for $c>2$ and $A=B$, involving the nonabelian tensor square of a group. (Received August 24, 2009)

1056-20-274 **Daniel Allen**, **Meghan Cream**, **Kate Finlay** and **Ranjan Rohatgi*** (ranjanrohatgi2007@u.northwestern.edu). *Complete Growth and Graph Products of Groups.*

The complete growth series of a finitely-generated group G is a formal power series, with coefficients in the group ring $\mathbb{Z}$G. In this talk we will explain what it means for such a power series to be *rational.* We then show that the property of being rational is preserved by graph products, a method of combining groups that is part way between free and direct products. This result generalizes a result of Chiswell from the 1990s. (Received August 24, 2009)

1056-20-277 **Joseph Kirtland*** (joe.kirtland@marist.edu), Department of Mathematics, Marist College, 3399 North Road, Poughkeepsie, NY 12601. *Finite Groups with Permutable Supplemented Subgroups.* Preliminary report.

A finite group $G = ABC$ for subgroups $A, B$, and $C$ of $G$ if for each element $g \in G$, then $g = abc$ where $a \in A, b \in B$, and $c \in C$. A finite group $G = (AB)C$ if $G = ABC$ and $AB$ is a subgroup of $G$. However, if $G = (AB)C$ it does not imply that $G = A(BC)$ or that $BC$ is a subgroup of $G$. This talk will investigate groups which do satisfy this transitivity condition ($G = (AB)C$ implies $G = A(BC)$) for proper subgroups. This examination will lead to a study of $p$-groups in which each subgroup not contained in the Frattini subgroup permutes with every other subgroup in the group. (Received August 24, 2009)

1056-20-371 **Mohammad K. Azarian*** (azarian@evansville.edu), Department of Mathematics, University of Evansville, 1800 Lincoln Avenue, Evansville, IN 47722. *Open Questions and Conjectures Regarding Near Frattini Subgroups of Generalized Free Products of Groups.* Preliminary report.

In this talk, first we will discuss some open questions regarding near Frattini subgroups of generalized free products of groups. Then, based on known results, we will present some conjectures concerning near Frattini subgroups of generalized free products of groups. (Received September 02, 2009)

1056-20-434 **Christopher P. Bendel*** (bendelc@uwstout.edu), MSCS Department, 721 East Third Street, Menomonie, WI 54751, **Daniel K. Nakano**, Department of Mathematics, University of Georgia, Athens, GA 30602, and **Cornelius Pillen**, Department of Mathematics and Statistics, University of South Alabama, Mobile, AL 36688. *Vanishing ranges for the cohomology of finite groups of Lie type.*

Let $G(\mathbb{F}_q)$ be a finite Chevalley group defined over the field of $q = p^r$ elements, and $k$ be an algebraically closed field of characteristic $p > 0$. A fundamental open and elusive problem has been the computation of the cohomology ring $H^\bullet(G(\mathbb{F}_q), k)$. In this talk, we will discuss recent work on determining initial vanishing ranges when $p$ is larger than the Coxeter number. For certain root systems, the first non-trivial cohomology classes are determined. The determination makes use of techniques involving line bundle cohomology for the flag variety $G/B$ and its relation to combinatorial data from Kostant Partition Functions. (Received September 07, 2009)

1056-20-450 **Robert M Guralnick*** (guralnic@usc.edu), Department of Mathematics, University of Southern California, 3620 S. Vermont Ave., Los Angeles, CA 90089-2532, and **Pham Huu Tiep**. *Low Degreel Cohomology for Finite Simple Groups.*

We will present some new upper bounds for low degree cohomology of finite simple groups. (Received September 08, 2009)

1056-20-474 **Nic Koban*** (nicholas.koban@maine.edu) and **Peter Wong** (pwong@bates.edu). *A relationship between the property $R_\infty$ and the geometric invariants $\Omega^n$.*

A group $G$ is said to have the property $R_\infty$ if every automorphism $\varphi \in \mathrm{Aut}(G)$ has an infinite number of $\varphi$-twisted conjugacy classes. Recent work of Gonçalves and Kochloukova uses the Bieri-Neumann-Strebel invariants $\Sigma^1(G)$ to show the property $R_\infty$ for a certain class of groups, including the generalized Thompson's groups $F_{0,n}$. In this talk, we make use of the invariants $\Omega^1(G)$ which are analogous to $\Sigma^1(G)$ to show the property $R_\infty$ for certain finitely generated groups. (Received September 09, 2009)

1056-20-497 **Vadim Ponomarenko*** (vadim@sciences.sdsu.edu), Department of Mathematics and Statistics, 5500 Campanile Dr., San Diego, CA 92182, and **Natalie Selinski**. *The Probability that Two Semigroup Elements Commute Can Be Anything.*

The *commuting probability* of a semigroup with $n$ elements is defined as the number of pairs of semigroup elements $(x, y)$ with $xy = yx$, divided by $n^2$. It is previously known that these probabilities are dense in $(0, 1]$, for various semigroups. We extend this result to show that these probabilities are in fact all rational numbers in $(0, 1]$. (Received September 10, 2009)

1056-20-499 **Hannah Alpert*** (hcalpert@uchicago.edu). *Finite Phase Transitions in Countable Abelian Groups.*

Let $A$ be an infinite set that generates a group $G$. The sphere $S_A(r)$ is the set of elements of $G$ for which the word length with respect to $A$ is exactly $r$. We say $G$ admits all finite transitions if for every $r \geq 2$ and every finite symmetric subset $W \subset G \setminus \{e\}$, there exists an $A$ with $S_A(r) = W$. We determine which countable abelian groups admit all finite transitions, and also show that $\mathbb{R}^n$ and the finitary symmetric group on $\mathbb{N}$ admit all finite transitions. (Received September 10, 2009)

1056-20-502 **Victor Ostrik*** (vostrik@uoregon.edu), 1222 University St, Department of Mathematics, University of Oregon, Eugene, OR 97403. *Blocks in Deligne's category $Rep(S_t)$.*

I will report on my joint work with J.Comes. Recently Deligne introduced the tensor category $Rep(S_t)$ which depends on a complex parameter $t$ and in a certain sense interpolates the representation categories of the symmetric groups. When $t$ is not a nonnegative integer, $Rep(S_t)$ is a semisimple category. When $t$ is a nonnegative integer, $Rep(S_t)$ is a non-semisimple non-abelian category. In this talk I will define the category $Rep(S_t)$ for arbitrary $t$, and describe its structure in the non-semisimple cases. (Received September 10, 2009)

1056-20-503 **Ruediger Goebel** (ruediger.goebel@uni-duisburg-essen.de), Fachbereich Mathematik, University of Duisburg-Essen, D 45117 Essen, Germany, **Katrin Leistner** (katrin.leistner@uni-duisburg-essen.de), Fachbereich Mathematik, University of Duisburg-Essen, D 45117 Essen, Germany, **Peter Loth*** (lothp@sacredheart.edu), Department of Mathematics, Sacred Heart University, Fairfield, CT 06825, and **Lutz Struengmann** (lutz.struengmann@uni-duisburg-essen.de), Fachbereich Mathematik, University of Duisburg-Essen, D 45117 Essen, Germany. *$L_\delta$-equivalence of $p$-local abelian groups with nice decomposition bases.*

Warfield groups are direct summands of simply presented abelian groups or, alternatively, are abelian groups possessing a nice decomposition basis with simply presented cokernel. They have been classified up to isomorphism by their Ulm-Kaplansky and Warfield invariants. Let $L_\delta$ denote the class of formulas in $L_{\infty\omega}$ with quantifier rank $\leq \delta$. In this paper, we classify up to $L_\delta$-equivalence a large class of $p$-local abelian groups having a nice decomposition basis. This generalizes results by Barwise and Eklof. (Received September 10, 2009)

1056-20-579 **Alexander Kleshchev** and **David Nash*** (dnash@uoregon.edu). *An interpretation of the LLT algorithm.*

We use graded Specht modules to calculate the graded decomposition numbers for the Iwahori-Hecke algebra of the symmetric group over a field of characteristic zero at a root of unity. The algorithm arrived at is the Lascoux-Leclerc-Thibon algorithm in disguise. Thus we interpret the algorithm in terms of graded representation theory. (Received September 16, 2009)

1056-20-592 **Eli Aljadeff*** (elialjadeff@gmail.com), Department of Mathematics, Technion-Israel Institute of Technology, Haifa, Israel, and **Ehud Meir** (meirehud@gmail.com), Department of Mathematics, Technion-Israel Institute of Technology, Haifa, Israel. *On subgroup induction in group representation and group cohomology.*

Elementary abelian subgroup induction plays a crucial role in cohomology and representation theory of finite groups. Roughly speaking, the results say that important cohomological properties hold for a group ring RG, G a finite group and R an arbitrary ring, if and only if they hold for RE where E runs over all elementary abelian subgroups of G. In general, similar statements are false if one replaces the family of elementary abelian subgroups by cyclics. For instance, a theorem due to Chouinard (1976) says that if G is a finite group and M is a RG-module then it is projective if and only if it is projective as an RE-module where E runs over all elementary abelian subgroups of G. In 1976, J. Moore posed a conjecture which generalizes Chouinard's theorem to arbitrary (not necessarily finite) groups. The following is a special (but important) case of the conjecture. Let G be a torsion free group and H a subgroup of finite index. Then an RG-module M is projective iff it is projective as an RH-module. Note that this implies Serre's theorem on cohomological dimension. In the lecture I will present some old results (joint work with Cornick, Ginosar and Kropholler) and some recent results (joint work with Ehud Meir). (Received September 14, 2009)

1056-20-645 **Leah Childers*** (leah@math.lsu.edu), Lockett Hall, Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Simply intersecting pairs in the mapping class group.*

The Torelli group, $\mathcal{I}$, is the subgroup of the mapping class group consisting of elements that act trivially on the homology of the surface. There are three types of elements that naturally arise in studying $\mathcal{I}$: bounding pair maps (BP-maps), separating twists, and simply intersecting pair maps (SIP-maps). Historically the first two types of elements have been the focus of the literature on $\mathcal{I}$, while SIP-maps have received relatively little attention until recently, due to an infinite presentation of $\mathcal{I}$ introduced by Andrew Putman that uses all three types of elements. We will show that the subgroup generated by SIP-maps is an infinite index subgroup of $\mathcal{I}$ and discuss further properties of this subgroup and its elements. (Received September 15, 2009)

1056-20-722 **Robert M. Guralnick** (guralnic@math.usc.edu), Department of Mathematics, University of Southern California, Los Angeles, CA 90089, and **Pham Huu Tiep*** (tiep@math.arizona.edu), Department of Mathematics, University of Arizona, Tucson, AZ 85721. *A problem of Kollár and Larsen on finite linear groups and crepant resolutions.* Preliminary report.

The notion of age of elements of complex linear groups was introduced by M. Reid and is of importance in algebraic geometry, in particular in the study of crepant resolutions and of quotients of Calabi-Yau varieties. In this paper, we solve a problem raised by J. Kollár and M. Larsen on the structure of finite irreducible linear groups generated by elements of age $\leq 1$. More generally, we bound the dimension of finite irreducible linear groups generated by elements of bounded deviation. As a consequence of our main results, we derive some

properties of symmetric spaces $GU_d(\mathbf{C})/G$ having shortest closed geodesics of bounded length, and of quotients $\mathbf{C}^d/G$ having a crepant resolution. (Received September 16, 2009)

1056-20-733 **Elizabeth Wilcox*** (wilcox@math.binghamton.edu), Binghamton University, Department of Mathematical Sciences, PO Box 6000, Binghamton, NY 13902. *Complete Groups: The Automorphism Tower and Some Characterizations.*

A group is complete if it has a trivial center and all of its automorphisms are inner, meaning they are induced by conjugation. H. Wielandt and J. S. Rose proved that all finite groups can be embedded in a finite complete group, through use of a series called the automorphism tower. This talk will give examples of complete groups, define the automorphism tower, and discuss characterizations of two types of complete semidirect products. (Received September 16, 2009)

1056-20-756 **Michael E. Orrison*** (orrison@hmc.edu), Department of Mathematics, Harvey Mudd College, 301 Platt Blvd., Claremont, CA 91711. *Algebraic Voting Theory.*

In this talk, I'll give a brief introduction to what might be called "algebraic voting theory." In particular, I'll show how the representation theory of the symmetric group can play a natural and sometimes surprising role when it comes to formulating and answering questions in voting theory. Along the way, I'll describe how this approach can say something interesting about tests of uniformity for rank data, and I'll introduce an intriguing and algebraically motivated extension of the Condorcet criterion. (Received September 16, 2009)

1056-20-782 **Nir Avni***, Department of Mathematics, Harvard University, Cambridge, MA 02138. *A Survey On Representation Zeta Functions.*

The Representation Zeta Function of a group $G$ is a generating function for the number of irreducible, $n$-dimensional representations of $G$. I will describe several surprising properties related to the poles, functional equations, and special values of these functions. (Received September 17, 2009)

1056-20-860 **David J Hemmer*** (dhemmer@buffalo.edu), 244 Mathematics Building, Buffalo, NY 14260. *A combinatorial approach to Specht module cohomology.*

We recently proved some stability type results for Specht module cohomology that resemble known generic cohomology results for algebraic groups. For example

$$\mathrm{H}^1(\Sigma_{pd}, S^{p\lambda}) \cong \mathrm{H}^1(\Sigma_{p^2d}, S^{p^2\lambda}).$$

The proofs use cohomology results for the Borel subgroup of the general linear group, and do not result in explicit isomorphisms. We will discuss the results and propose a new combinatorial proof that seems to work in many cases. (Received September 18, 2009)

1056-20-861 **Brian Parshall*** (bjp8w@virginia.edu), Dept. of Mathematics, University of Virginia, Charlottesville, VA 22903. *Support varieties and complexity for algebraic, finite, and quantum groups.* Preliminary report.

We first describe the computation of support varieties of *all* irreducible modules for small quantum groups $u_\zeta(\mathfrak{g})$, at an $\ell$-th root of unity, $\ell > h$, the Coxeter number. A similar calculation holds, replacing $u_\zeta(\mathfrak{g})$ by the restricted enveloping algebra $u(\mathfrak{g})$ of a simple, simply-connected algebraic group $G$ over an algebraically closed field of characteristic $p > 0$. This result assumes that $p \geq h$ and that the Lusztig character formula holds for all restricted dominant weights. Thus, it holds for $p$ sufficiently large, as well as some notable other cases. This part of the talk is joint work with Chris Drupieski and Dan Nakano.

The complexity of a finite dimensional module $M$ for a finite group $H$ is the growth rate of $\dim \mathrm{Ext}^n_H(M, \oplus_{L\,\mathrm{irred}} L)$. It is closely related to support variety theory. We propose a complexity theory for the *big* quantum group $U_\zeta$, and describe applications to Kazhdan-Lusztig polynomials. These ideas are related to Koszul structures associated to the full Ext-algebra of $U_\zeta$. This part of the talk is joint work with Leonard Scott. (Received September 18, 2009)

1056-20-867 **Jon F Carlson*** (jfc@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602, and **Eric M Friedlander** and **Julia Pevtsova**. *Bundles and submodule functors.* Preliminary report.

In this talk we consider generic constructions of submodule and their relations to modules of constant Jordan type over finite group schemes. The submodule constructions are functorial and construct submodules that can be used to define bundles over projective spaces and Grassmanians. This is work in progress. (Received September 18, 2009)

1056-20-877 **Luise-Charlotte Kappe**, **Marcin Mazur**, **Gabriela Mendoza** and **Michael B. Ward*** (wardm@wou.edu), Mathematics Department, Western Oregon University, Monmouth, 97361. *On solvable minimal non-p-closed and non-p-exponent closed groups.*

Let p be a prime. A group is called $p$-closed if it has a normal Sylow $p$-subgroup and it is called $p$-exponent closed if the elements of order dividing p form a subgroup. Let E be a group theoretic property. We say a group is a minimal non-E-group, if it is not an E-group but its proper subgroups and proper homomorphic images are E-groups.

We present the (somewhat surprising) relationship between the classes of minimal non-$p$-closed and minimal non-$p$-exponent closed groups. Those classes contain only solvable and simple groups. We focus on solvable groups. The simple groups will be discussed in another talk at these meetings. (Received September 18, 2009)

1056-20-1001 **Leonard L Scott***, Dept. Mathematics, The University of Virgina, Kerchof Hall, Cabell Drive, Charlottesville, VA 22903. *Some 1- and n-cohomology results for finite and algebraic groups.*

This talk will discuss recent results in collaboration with Brian Parshall, and also with Cline and Parshall, and with Nanhua Xi, dealing with dimension bounds for 1-cohomology and $\mathrm{Ext}^1$ for algebraic groups and finite groups of Lie type with irreducible coefficients, as well as some new results with Parshall dealing with cohomology and Ext in higher degree. The general area of these results, which perhaps began with a 1984 conjecture by Bob Guralnick, has seen considerable activity recently, with contributions to cross-characteristic in the finte group 1-cohomology case by Guralnick and Tiep, and questions raised for higher degree cohomomology by Guralnick, Kantor, Kassabov, and Lubotsky. Quantum groups play a big role in the new work with Parshall (and in previous work with Cline and Parshall) and a number of related results will also be presented for quantum groups. Another ingredient, especially useful for dealing with singular weights in the algebraic groups case, is a new kind of derived category filtration, in some sense generalzing the notion of a "good" (costandard) filtration in algebraic groups module categories. (Received September 19, 2009)

1056-20-1061 **Charles E Buehrle*** (ceb405@lehigh.edu), Lehigh University, Department of Mathematics, 14 E. Packer Ave., Bethlehem, PA 18015. *Representations of the Iwahori-Hecke algebra of the symmetric group.*

We use new vanishing results on elements of the dual canonical basis of the quantum polynomial ring to construct representations of the Iwahori-Hecke algebra. We then show that these representations are equivalent to representations due to D. Kazhdan and G. Lusztig, except we can avoid the defining the Hecke algebra modules as quotients. (Received September 20, 2009)

1056-20-1204 **Shmuel Rosset*** (shro@post.tau.ac.il), Mathematics, Tel Aviv University, Tel Aviv, Israel. *The Hall index of a subgroup of a free group.*

The Hall index of a finitely generated subgroup of a free group was defined by Marshall Hall. It is difficult to compute or estimate. The Kurosh subgroup theorem implies it is submultiplicative, in the sense that the Hall index of an intersection is less than or equal the product of the Hall indices. This gives bounds on the rank of such intersections. (Received September 21, 2009)

1056-20-1247 **Luise-Charlotte Kappe*** (menger@math.binghamton.edu), Department of Mathematical Sciences, PO Box 6000, Binghamton, NY 13902-6000, **Marcin Mazur**, NY, and **Gabriela Mendoza** and **Michael B Ward**. *On simple minimal non-p-closed and non-p-exponent closed groups.*

Let $p$ be a prime. A group is called $p$-closed if it has a normal Sylow $p$-subgroup and it is called $p$-exponent closed if the elements of order dividing $p$ form a subgroup. Let $E$ be a group theoretic property. We say a group is a minimal non-$E$-group, if it is not an $E$-group but its proper subgroups and homomorphic images are. We explore minimal non-$E$-groups in the case $E = p$-closed and $E = p$-exponent closed and investigate their connections. Those classes contain only solvable and simple groups. In this talk we focus on simple groups. The solvable groups will be discussed in another talk at these meetings. Using the classification of finite simple groups, simple minimal non-$p$-closed groups can be determined for $p < 11$. In these cases, any minimal non-$p$-closed group is also minimal non-$p$-exponent closed. It is an open question wether this is true in general for simple groups and arbitrary $p$. In general we can say that both kinds of groups have cyclic Sylow $p$-subgroups. (Received September 21, 2009)

1056-20-1265 **Luise-Charlotte Kappe** and **Viji Thomas*** (vthomas@math.binghamton.edu), Department of Mathematical Sciences, PO Box 6000, Binghamton, NY 13902-6000. *On the nonabelian tensor product of finite groups of relatively prime order.* Preliminary report.

Given two finite abelian groups of relatively prime order, it is well known that their tensor product is trivial. We give an example of two finite abelian groups of relatively prime order whose nonabelian tensor product is nontrivial. We investigate necessary as well as sufficient conditions when the nonabelian tensor product of two finite groups of relatively prime order is trivial. (Received September 21, 2009)

1056-20-1365 **Ricardo Portilla*** (ricarpor@umich.edu). *Parametrizing Nilpotent Orbits in Symmetric Spaces Using Bruhat-Tits Theory.*

Let $k$ be a field equipped with a nontrivial discrete valuation. Suppose $k$ is complete and that its residue field is perfect. Let $G$ be the group of $k$-rational points of a connected reductive linear algebraic group defined over $k$, and let $\theta$ be an involution of $G$. We denote by $H$ the set of points in $G$ which are fixed under $\theta$. If $\mathfrak{g}$ denotes the Lie algebra of $G$, then $\theta$ induces an involution $d\theta$ on the Lie algebra $\mathfrak{g}$. Denote by $\mathfrak{p}$ the $(-1)$-eigenspace of $\mathfrak{g}$ under $d\theta$ and fix $r \in \mathbb{R}$. We will discuss a parametrization of nilpotent $H$-orbits in $\mathfrak{p}$ by (a symmetric space analogue of) distinguished degenerate Moy-Prasad cosets of depth $r$ up to some natural equivalence relation. (Received September 21, 2009)

1056-20-1376 **Carrie Jean Tirel*** (carries@uwm.edu), Department of Mathematical Sciences, University of Wisconsin - Milwaukee, 3200 N. Cramer St., Milwaukee, 53211. *On $\mathcal{Z}$-Structures of Groups.* Preliminary report.

A *$\mathcal{Z}$-structure* on a group $G$, defined by M. Bestvina, is essentially a pair $(\tilde{X}, Z)$ of spaces such that $\tilde{X}$ is a compact AR, $Z$ is a $\mathcal{Z}$-set in $\tilde{X}$, $G$ acts properly discontinuously and cocompactly on $X = \tilde{X} \backslash Z$, and the collection of translates of any compact set in $X$ forms a null sequence in $\tilde{X}$. It is natural to ask whether a given group admits a $\mathcal{Z}$-structure. In this talk, we will investigate whether direct products, free products, and certain free products with amalgamation admit $\mathcal{Z}$-structures under the hypothesis that each factor admits such a structure. (Received September 21, 2009)

1056-20-1381 **Cody L Patterson*** (cpatters@math.utexas.edu), 10610 Morado Circle, Apartment 2401, Austin, TX 78759. *Some Coxeter groups of CAT(0) dimension three.*

The Coxeter FA$_n$ conjecture states that a Coxeter group $W$ acts by isometries on a CAT(0) polyhedral cell complex of dimension $n$ without global fixed points if and only if $W$ has an infinite special subgroup of rank $n+1$. This conjecture has been proven for $n = 1$ by Serre and for $n = 2$ by A. Barnhill. I will discuss some classes of Coxeter groups with infinite special subgroups of rank 4 that act without global fixed points on CAT(0) cell complexes of dimension 3. (Received September 21, 2009)

1056-20-1461 **Jason Elliot*** (jason.elliot@gmail.com), 1806 Park Haven Drive, Champaign, IL 61820. *Central Extensions of Divisible Groups.*

Central extensions are easier to understand than general extensions because the kernel is a trivial module for the quotient. The Universal Coefficient Theorem becomes helpful, especially when the kernel is divisible. Moreover, such extensions are universal in the sense that they contain copies of all central extensions. Particularly, a nilpotent group of class $c$ embeds into such an extension with quotient of class $c - 1$. We pay special attention to the case when the quotient is abelian. (Received September 21, 2009)

1056-20-1483 **Joel Louwsma*** (louwsma@caltech.edu), Department of Mathematics 253-37, California Institute of Technology, Pasadena, CA 91125. *Stable Commutator Length in Braid Groups.* Preliminary report.

We study stable commutator length in, and extremal quasimorphisms on, braid groups. After introducing these concepts, we explain our algorithm for computing stable commutator length in the three-strand braid group. Then we discuss how these techniques may or may not generalize to higher-strand braid groups. (Received September 21, 2009)

1056-20-1598 **Daniel A Daly*** (ddaly@semo.edu), Southeast Missouri State University, Dept. of Mathematics, MS 6700, One University Plaza, Cape Girardeau, MO , and **Petr Vojtechovsky**. *Enumerating Nilpotent Loops.*

We will discuss the isomorphism problem for centrally nilpotent loops. Using techniques from cohomology and linear algebra, we can enumerate the isomorphism classes for nilpotent loops of order n for n $<$ 24 and of order 2p for p a prime. This research is heavily computer aided and we will discuss how to teach a computer to count nilpotent loops. (Received September 22, 2009)

1056-20-1655 **Margaret H. Dean*** (mdean@bmcc.cuny.edu), BMCC Math Department, 199 Chambers Street, Room N524, New York, NY 10007. *The free metabelian product of a free nilpotent group with a free abelian group.*

If two groups are residually-$\mathcal{P}$, their free product is not necessarily so; however, it is known that the free product of residually torsion-free nilpotent groups is again residually torsion-free nilpotent. In this talk, I will discuss a new result for free metabelian products; namely, that the free metabelian product of a free nilpotent group of class two with a free abelian group is residually torsion-free nilpotent. (Received September 22, 2009)

1056-20-1659 **Marcos Zyman*** (mzyman@bmcc.cuny.edu), 199 Chambers St., New York, NY 10007, and **Stephen Majewicz**, 2001 Oriental Boulevard, Brooklyn, NY 11235. *Localization and extraction of roots in nilpotent R-powered groups.* Preliminary report.

Let $R$ be a binomial ring. A nilpotent group which comes equipped with an $R$-action, and satisfies certain desirable axioms is termed an *R-powered nilpotent group.* I will discuss some extensions of the theories of localization and radicable nilpotent groups to the broader class of nilpotent R-powered groups. If $\pi$ is a prime in $R$, I will define such local notions as $\pi$-monomorphisms and $\pi$-epimorphisms, and explain how they relate to root extraction in nilpotent $R$-powered groups. (Received September 22, 2009)

1056-20-1740 **Keith Michael Jones*** (kjones@math.binghamton.edu), 21 Andrea Dr. apt A, Vestal, NY 13850. *An introduction to the Bieri-Neumann-Strebel Invariant for finitely generated groups.*

For a finitely generated group $G$, the Bieri-Neumann-Strebel invariant is a topological invariant $\Sigma^1(G)$ that provides a measure of "connectedness with respect to direction" in the Cayley graph. Among other applications, $\Sigma^1(G)$ can be used to determine whether the kernel of a homomorphism from $G$ to an abelian group is finitely generated. In their 1987 paper, Bieri, Neumann, and Strebel introduced the invariant, along with a compelling application in the form of the following theorem:

**Theorem.** *If a finitely presented group $G$ has no nonabelian free subgroups and $rk_{\mathbb{Z}}(G^{ab})\geq 2$, then there is a short exact sequence $N \hookrightarrow G \twoheadrightarrow \mathbb{Z}$, where $N$ is finitely generated.*

I will introduce $\Sigma^1$ and sketch the proof this theorem. (Received September 22, 2009)

1056-20-1766 **Michael Kinyon*** (Michael.Kinyon@du.edu), Department of Mathematics, 2360 S Gaylord St, University of Denver, Denver, CO 80208, and **Wolfgang Bertram** (bertram@iecn.u-nancy.fr), Institut Élie Cartan Nancy, Nancy-Université, Nancy, France. *Associative Geometry.*

Corresponding to any associative algebra, or more generally, to any associative pair, is a geometric object called an *associative geometry.* Conversely, to any associative geometry, there is a (functorially constructed) corresponding associative pair. The associative geometry of a unital associative algebra $\mathbb{A}$ is the Grassmannian of right $\mathbb{A}$-modules in $W = \mathbb{A} \oplus \mathbb{A}$ equipped with a certain (ternary) semigroup structure. This global semigroup structure specializes to the standard (ternary) abelian group structure on the set of all complements to a given submodule, and it also includes the (general linear) group of transformations of $W$. In fact, an associative geometry is a canonical semigroup completion of a general linear group and its homotopes, viewed as sitting inside an associative algebra. Taking involutions of associative algebras and associative geometries into account, we can construct canonical semigroup completions for all classical groups and their homotopes (and, in certain cases, for their analogs in infinite dimension or over general base fields or rings). (Received September 22, 2009)

1056-20-1782 **Lenny Jones** (lkjone@ship.edu), Department of Mathematics, Shippensburg University, 1871 Old Main Drive, Shippensburg, PA 17257, and **Kelly Toppin*** (kt5638@ship.edu), Department of Mathematics, Shippensburg University, 1871 Old Main Drive, Shippensburg, PA 17257. *On Some Conjectures Concerning Groups With Perfect Order Subsets.* Preliminary report.

Let $G$ be a finite group, and for any element $x$ of $G$, define the **order subset** of $G$ determined by $x$ to be the set of all elements in $G$ with the same order as $x$. We say that $G$ has **perfect order subsets** if the number of elements in each order subset of $G$ divides the order of $G$. In this talk, we discuss some open questions concerning groups with perfect order subsets. (Received September 22, 2009)

1056-20-1895 **David G Radcliffe*** (david.radcliffe@century.edu), Mathematics Department, 3300 Century Ave N, White Bear Lake, MN 55110. *Hyperreflection groups.*

We generalize the definition of Coxeter group to include a wider class of groups, called hyperreflection groups. These groups are similar enough to Coxeter groups that many of the techniques in Coxeter group theory can be adapted to hyperreflection groups. At the same time, the definition is general enough to include other interesting groups, such as graph products and Artin groups. (Received September 22, 2009)

1056-20-1991 **Lourdes Juan*** (lourdes.juan@ttu.edu), Department of Mathematics, Texas Tech University, Box 1042, Lubbock, TX 79409, and **Andy R. Magid**. *Differential 'Galois' extensions with new constants.*

Let $F$ be a differential field with algebraically closed field of constants $\mathcal{C}$ and let $E$ be a differential field extension of $F$. $E$ is a differential Galois extension if it is generated over $F$ by a full set of solutions of a linear homogeneous differential equation with coefficients in $F$ and its field of constants coincides with $\mathcal{C}$. We study the differential field extensions $E$ of $F$ that satisfy the first condition but not the second. Our main result shows that nonetheless $E$ is much like a differential Galois extension of $FK$, where $K$ is the field of constants of $E$. In particular, we find an algebraic subgroup $G$ of $\mathrm{GL}_n(K)$ with $E^G = FK$. (Received September 22, 2009)

1056-20-2114 **Selin Kalaycioglu*** (kalaycioglus@kenyon.edu), 6 Craig Dr., Mount Vernon, OH 43050. *Computing the Projective Indecomposable Modules of large Finite Groups.*

Let $G$ be a finite group and $\mathbb{F}$ be a finite field.A projective indecomposable $\mathbb{F}G$-module (P.I.M.) is an indecomposable direct summand of the group algebra $\mathbb{F}G$. Computing the P.I.M.s of large finite groups has been always a challenging problem due to the large sizes of the representations of these groups.The theory of Morita and condensation are used for constructing the P.I.M.s of some finite groups,however there are limitations on the sizes of the representations that these techniques can be applied to.This paper describes a new method for constructing the P.I.M.s of large finite groups.The power of the algorithm is illustrated by the examples of the socle series of all P.I.M.s of the sporadic simple Mathieu group $M_{24}$ and the alternating group $A_{12}$ in characteristic 2. This new technique allows for further analysis of large finite simple groups and their representations.These results have direct applications in other areas of Algebra;for example,a known scheme for computing the Ext-algebra for simple groups and computing the cohomology groups of $FG$-modules via projective resolutions depends upon knowing the P.I.M.s of $G$.This method for calculating the P.I.M.s presents an opportunity to extend these techniques to larger groups. (Received September 23, 2009)

# 22 ► Topological groups, Lie groups

1056-22-117 **Luis Alberto Lomeli*** (llomeli@math.uiowa.edu), Department of Mathematics, The University of Iowa, 15 MacLean Hall, Iowa City, IA 52242. *On the Langlands-Shahidi method for the classical groups in non-zero characteristic and applications.* Preliminary report.

Let $F$ be a non-archimedean local field of positive characteristic and let $G$ be either a split classical group or a quasi-split unitary group. Fix a Borel subgroup of $G$ and let $P = MN$ be a standard parabolic subgroup with Levi $M$. The Langlands-Shahidi method is developed over global function fields in order to understand $L$-functions and root numbers arising from generic representations of $M(F)$. It is then possible to obtain applications including an extension to characteristic $p$ of Shahidi's proof of Langlands' conjecture on the normalization of intertwining operators as well as his result on complementary series. (Received July 28, 2009)

1056-22-136 **Paul Frank Baum*** (baum@math.psu.edu), Mathematics Department, McAllister Building, Pennsylvania State University, University Park, PA 16802. *Geometric Structure in the Representation Theory of Reductive p-adic Groups.*

Let $G$ be a reductive p-adic group. The admissible dual of $G$ is the set of equivalence classes of smooth irreducible representations of $G$. Contained within the admissible dual is the tempered dual of $G$, i.e. the set of equivalence classes of smooth irreducible representations of $G$ having tempered Harish-Chandra character. The admissible dual of $G$ is in bijection with $Prim(HG)$ where $HG$ denotes the Hecke algebra of $G$. Thus $HG$ is the convolution algebra of all locally-constant compactly-supported complex-valued functions on $G.Prim(HG)$ denotes the set of primitive ideals in $HG$. If $Prim(HG)$ is given the Jacobson topology, $Prim(HG)$ is then the disjoint union of its connected components. These connected components are known as the Bernstein components. This talk explains a conjecture due to A.M.Aubert, P.F.Baum and R.J.Plymen. According to the conjecture, each Bernstein component is a complex affine variety. These varieties are explicitly identified as extended quotients. The tempered representations within each Bernstein component form the associated compact orbifold extended quotient. The conjecture is based on the theory of the Bernstein center, and if correct further develops this theory. (Received July 31, 2009)

1056-22-203 **Lisa Carbone**, **Leigh Cobbs*** (cobbs@lvc.edu) and **Scott Murray**. *Fundamental domains for congruence subgroups of $SL_2$ in positive characteristic.*

When groups act on graphs, quotient "graphs of groups" are produced. One attempt at constructing infinite families of expander graphs tried to find graphs of groups for congruence subgroups of $\Gamma = PGL_2(\mathbb{F}_q[t])$. There was an error, which we explain and repair. We use the method of ramified coverings to construct graphs of groups for congruence subgroups of $SL_2(\mathbb{F}_q[t])$ and give explicit examples. We thus provide new families of graphs whose level 0 - 1 subgraphs potentially have the expansion properties claimed previously. (Received August 14, 2009)

1056-22-311 **Neil Hindman*** (nhindman@aol.com) and **Dona Strauss** (d.strauss@hull.ac.uk). *Homomorphisms on compact subsets of $\beta S$.*

Let $S$ and $T$ be infinite discrete semigroups, let $\mathcal{A} \subseteq \mathcal{P}(S)$, and assume that $\mathcal{A}$ has the finite intersection property. Let $f : S \to T$ and let $\widetilde{f} : \beta S \to \beta T$ be its continuous extension. We obtain necessary and sufficient conditions for the restriction of $\widetilde{f}$ to $\bigcap_{A\in\mathcal{A}} c\ell_{\beta S}(A)$ to be a homomorphism and to be injective. We also investigate when the image of an idempotent must be an idempotent. (Received August 27, 2009)

1056-22-348 **Bin Wang** and **Xinyun Zhu*** (zhu_x@utpb.edu), Xinyun Zhu, Department of Mathematics, UTPB, Odessa, TX 79762. *Whittaker Modules for a Lie Algebra of Block Type.*

In this paper, we study Whittaker modules for a Lie algebras of Block type. We define Whittaker modules and under some conditions, obtain a one to one correspondence between the set of isomorphic classes of Whittaker modules over this algebra and the set of ideals of a polynomial ring, parallel to a result from the classical setting and the case of the Virasoro algebra (Received September 01, 2009)

1056-22-463 **Fiona Murnaghan*** (fiona@math.toronto.edu), Department of Mathematics, University of Toronto, 40 Saint George Street, Toronto, Ontario M4S 2E4, Canada. *Distinguished representations of reductive p-adic groups.* Preliminary report.

Let $G$ be a connected reductive $p$-adic group, and let $\theta$ be an involution of $G$. Let $H$ be the group of fixed points of $\theta$ in $G$. A smooth representation $\pi$ of $G$ is said to be $H$-distinguished (or $\theta$-distinguished) if there exists an $H$-invariant linear functional on the space $V$ of $\pi$. If $\lambda$ is an $H$-invariant element of $V^*$ and $v$ belongs to $V$, the function $g \mapsto \langle\, \lambda,\, \pi(g)v\, \rangle$ is called a generalized matrix coefficient of $\pi$ relative to $H$. If $\pi$ is $H$-distinguished, $\pi$ is said to be $H$-relatively supercuspidal if all of the generalized matrix coefficients of $\pi$ (relative to $H$) are compactly supported modulo $HZ$, where $Z$ is the centre of $G$. We will discuss some results and some open questions concerning relatively supercuspidal representations of reductive $p$-adic groups. (Received September 08, 2009)

1056-22-724 **Kendall Williams*** (kendallwilliams1983@yahoo.com). *Members of sums of idempotents in $\beta\mathbb{N}$.* Preliminary report.

Let $(S, \cdot)$ be a discrete semigroup. One may extend the operation on $S$ to $\beta S$, the Stone-Čech compactification of $S$, making $(\beta S, \cdot)$ a compact right topological semigroup. If $a_1, a_2, ..., a_k \in \mathbb{Z}$ with $a_k > 0$ and $p = p + p \in \beta\mathbb{N}$, then $a_1 p + a_2 p + ... + a_k p \in \beta\mathbb{N}$. If $A \in a_1 p + a_2 p + ... + a_k p$, then there is a sequence $\langle x_t\rangle_{t=1}^{\infty}$ in $\mathbb{N}$ such that whenever $F_1, F_2, ..., F_k$ are finite subsets of $\mathbb{N}$ with $\max F_i < \min F_{i+1}$ for all $i \in \{1, 2, ..., k-1\}$, one has $\sum_{i=1}^{k} a_i \sum_{t\in F_i} x_t \in A$. We investigate what expressions must lie in members of $a_1 p_1 + a_2 p_2 + ... + a_k p_k$ where $p_1, p_2, ..., p_k$ are idempotents, not necessarily the same. For example, we show that if $p$ and $q$ are idempotents and $A \in a_1 p + a_2 q + a_3 p$, then there exist sequences $\langle x_t\rangle_{t=1}^{\infty}$ and $\langle y_t\rangle_{t=1}^{\infty}$ such that whenever $F_1, F_2$, and $F_3$ are finite subsets of $\mathbb{N}$ with $\max F_1 < \min F_2$ and $\max F_2 < \min F_3$, one has $a_1 \sum_{t\in F_1} x_t + a_2 \sum_{t\in F_2} y_t + a_3 \sum_{t\in F_3} x_t \in A$. (Received September 16, 2009)

1056-22-825 **Paul J Sally*** (sally@math.uchicago.edu), 5734 S. University Ave, Chicago, IL 60616, and **Loren Spice**. *Characters Tell All: The Plancherel Formula Done Right.* Preliminary report.

We discuss the Fourier transform of orbital integrals on reductive groups over a local field. The Plancherel Formula is then derived through a limiting process. (Received September 22, 2009)

1056-22-829 **Steven T Spallone*** (sspallone@math.ou.edu). *An Integral Formula of Shahidi.*

Let $\tilde{G}$ be a unitary or classical group over a local field of characteristic 0, and $P = MN$ a parabolic subgroup. Then $M$ may be written as a product of groups $G \times H$, with $G$ a general linear group, and $H$ a reductive group of the same kind as $\tilde{G}$. In this talk we study the case in which $G$ and $H$ naturally act on vector spaces of the same dimension (in other words they are viewed as groups of matrices of the same size). In this case, we decompose the Haar measure $dn$ on $N$. We do this by choosing orbit representatives for the adjoint action of $M$ on $N$, via a "norm correspondence", parametrizing these orbits by regular semisimple elements in $H$. The decomposition of this integral has application to computing the residues of intertwining operators of induced representations of $\tilde{G}$. (Received September 17, 2009)

1056-22-1028 **Andrei Minchenko*** (andreim@math.cornell.edu), Department of Mathematics, Malott Hall, Cornell University, Ithaca, NY 14853, and **Alexey Ovchinnikov**. *Zariski closures of linear differential algebraic groups.*

Linear differential algebraic groups appear as Galois groups of systems of linear differential equations with parameters. These groups measure differential algebraic dependencies among solutions of such equations. As in other Galois theories, various properties of such groups determine the corresponding properties of the solutions. We will discuss how computing the Zariski closures of linear differential algebraic groups can exhibit their properties considering the classes of simple and reductive linear differential algebraic groups. (Received September 20, 2009)

1056-22-1046 **Raf Cluckers**, **Clifton Cunningham** and **Julia Gordon*** (gor@math.ubc.ca), Department of Mathematics, UBC, 121-1984 Mathematics Rd., Vancouver, BC V6T 1Z2, Canada, and **Loren Spice**. *Motivic integration and Harish-Chandra characters.* Preliminary report.

I will prove that the characters of a certain class of supercuspidal representations near the identity belong to the class of so-called constructible motivic exponential functions. Functions in this class are defined in terms of a language of logic, and that allows to define them in a field-independent way. Therefore, one can transfer the results about constructible motivic functions between local fields of characteristic zero, and local fields of positive characteristic, when the residue field characteristic is large. Having established that certain characters belong to this class, I will describe some recent attempts to use this result to study their local constancy and local inegrability. (Received September 20, 2009)

1056-22-1293 **Monica Nevins*** (mnevins@uottawa.ca), Department of Mathematics and Statistics, 585 King Edward Ave., Ottawa, ON K1N 6N5, Canada. *Some irreducible representations of SL(2,O), where O is the integer ring of a p-adic field.* Preliminary report.

The restriction of an irreducible representation of SL(2,k) to the maximal compact subgroup SL(2,O) is far from irreducible, but its decomposition into irreducibles is multiplicity-free. We report on recent progress on the problem of how families of irreducibles of SL(2,O) arise in this way. (Received September 21, 2009)

1056-22-1435 **Ju-Lee Kim*** (julee@math.mit.edu), 77 Massachusetts Av, MIT, 2-281, Cambridge, MA 02139. *An application of Gamma asymptotic expansions.* Preliminary report.

Using a Gamma asymptotic expansion, which is a character expansion reflecting an information about types contained in a given irreducible admissible representation, we calculate Plancherel measures in some cases. (Received September 21, 2009)

1056-22-1764 **Joshua M Lansky*** (lansky@american.edu), Department of Mathematics and Statistics, American University, 4400 Massachusetts Avenue, NW, Washington, DC 20016-8050, and **Jeffrey L Hakim** (jhakim@american.edu), Department of Mathematics and Statistics, American University, 4400 Massachusetts Avenue, NW, Washington, DC 20016-8050. *Tame supercuspidal representations of* GL($n$) *distinguished by orthogonal groups.*

For a nonarchimedean local field $F$, let $G = \mathrm{GL}(n, F)$ and let $H \subset G$ be the stabilizer group of a nondegenerate symmetric bilinear form over $F$. We determine the tame supercuspidal representations of $G$ distinguished by $H$. In many cases, we also determine the dimension of $H$-invariant linear forms on these representations. (Received September 22, 2009)

1056-22-1820 **Jeffrey D Adler*** (jadler@american.edu), Department of Mathematics and Statistics, 4400 Massachusetts Ave NW, Washington, DC 20016-8050, and **Stephen M. DeBacker**, Department of Mathematics, 2074 East Hall, 530 Church St, Ann Arbor, MI 48109-1043. *Tamely ramified tori.* Preliminary report.

From earlier work of the second-named author, one can parametrize unramified tori in a reductive $p$-adic group $G$ using data that come from the Bruhat-Tits building of $G$. Here we present some work in the direction of a generalization to tamely ramified tori. (Received September 22, 2009)

1056-22-2018 **Yu Jiu-Kang*** (jyu@math.purdue.edu), Department of Mathematics, Purdue University, West Lafayette, IN 47906. *On the Heisenberg groups and Weil representations in characteristic 2.* Preliminary report.

The theory of finite Heisenberg groups and Weil representations is well-known in odd characteristic, and has important applications to the theory of types and supercuspidal representations. We will give an extension of this theory that works in all characteristic. (Received September 22, 2009)

1056-22-2035 **Stephen M DeBacker***, Department of Mathematics, 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109-1043. *Invariant distributions supported on compact elements.*

If J denotes the space of invariant distributions supported on the set of compact elements in a reductive p-adic group G and D denotes the space of bi-Iwahori invariant functions on G, can one describe a basis for the restriction to D of J? I will discuss what is known about this problem, and I will introduce some related problems on finite groups of Lie type. (Received September 22, 2009)

# 26 ► Real functions

1056-26-46 **Houshang H Sohrab*** (hsohrab@towson.edu), Department of Mathematics, Towson University, 8000 York Road, Towson, MD 21252-0001. *Subpolynomial and Subexponential Functions.* Preliminary report.

We shall discuss necessary conditions for real-valued functions on the Euclidean $n$-space to be subpolynomial (i.e., satisfy $f(x) = o(|x|^m)$, as $|x| \to \infty$, for a positive integer $m$) or subexponential (i.e., satisfy $f(x) = o(e^{\varepsilon|x|})$, as $|x| \to \infty$, for all $\varepsilon > 0$). In the subeponential case, the condition is one of the various (necessary and sufficient) conditions for hypoellipticity of polynomials in several variables. Using another such condition we indicate how a subexponential function can be "smoothed" and also discuss the spectra of second order self-adjoint differential operators with subexponential coefficients. (Received July 13, 2009)

1056-26-104 **Maxim Zinchenko*** (maxim@caltech.edu). *On the Hilbert Transform of a Measure.*

We give a criterion for pure absolute continuity of a measure in terms of its Hilbert transform. Explicitly, we prove that $\lim_{t\to\infty} t|E \cap \{x : |H_\mu(x)| > t\}| = 0$ if and only if $\mu_s(E) = 0$, where $\mu$ is a finite positive measure on $\mathbb{R}$, $\mu_s$ its singular part, $H_\mu$ its Hilbert transform, and $E \subset \mathbb{R}$ is a homogeneous set in the sense of Carleson. The result has applications in the spectral theory of Schödinger, Jacobi, and CMV operators.

This is joint work with Alexei Poltoratski and Barry Simon. (Received July 27, 2009)

1056-26-613 **Padraig M. McLoughlin*** (mcloughl@kutztown.edu), 265 Lytle Hall, Department of Mathematics, Kutztown University of Pennsylvania, Kutztown, PA 19530, and **Christopher R. Krizan** (crk0010@auburn.edu), 200 Mell Hall, Department of Mathematics, Auburn University, Auburn, AL 36849. *Aspects of Stochastic Quasi-Cantoresque Sets.* Preliminary report.

We begin with a brief synopsis of where our work originated, the classic Cantor middle-third set, $\mathcal{C}$, and then discuss Cantoresque sets, quasi-Cantoresque sets, and introduce the quasi-Cantoresque sets that Krizan created, the Krizan Set $\mathcal{K}$, and the Bubba Set, $\mathcal{B}$. We then build on that and create stochastic quasi-Cantoresque sets and explore aspects of and prove some nice results on stochastic quasi-Cantoresque sets.

We conclude with some conjectures and discuss where our research is leading. We note that there are evidently more questions raised by the research than questions answered by the results. (Received September 14, 2009)

1056-26-1044 **Nasser Dastrange*** (dastrange@bvu.edu), Buena Vista University, 610, West Fourth Street, Storm Lake, IA 50588. *Mean Value Theorem for Functions on the Complex Plane.* Preliminary report.

It is well known that Rolle's Theorem is not valid for holomorphic functions of a complex variable.

In this talk we will discuss a generalization of Rolle's Theorem to holomorphic functions of a complex variable. Furthermore, we will establish the complex mean value theorem.

Additionally, some interesting properties, recent research, and several examples of the complex mean value theorem will be presented. (Received September 20, 2009)

1056-26-1354 **J Marshall Ash*** (mash@math.depaul.edu), DePaul University, Mathematics Department, Chicago, IL 60614. *An analogue of L'Hospital's rule.*

L'Hospital's well known rule asserts that under certain conditions, the existence of a limit for $f'(x)/g'(x)$ implies the existence of the same limit for $f(x)/g(x)$ .An analogous rule for series is this. Suppose $f$ and $g$ are functions such that $f, g \to 0$ at infinity, $g(n)g'(n)$ is nonzero for all natural numbers $n$, and in some neighborhood of infinity $g'$ is nonzero and $|f'(x)/g'(x)|$ is decreasing. If $\sum_{n=1}^{\infty} |f'(n)/g'(n)|$ converges, then $\sum_{n=1}^{\infty} f(n)/g(n)$ converges. A simple example shows that the conclusion may no longer be true if the assumption $f, g \to 0$ at infinity is replaced by the assumption $f, g \to \infty$ at infinity. (Received September 21, 2009)

# 28 ► Measure and integration

1056-28-1677 **Kevin R. Vixie*** (vixie@speakeasy.net). *Multiscale Flat Norm Shape Signatures.*

The discovery that the L1TV or TVL1 Functional computes the flat norm for co-dimension one boundaries permits us to compute novel shape signatures through the multiscale flat norm that this discovery introduced. In this talk I explore the applications of this discovery as well as aspects of the computation of the flat norm for boundaries using graph cut methods. (Received September 22, 2009)

# 30 ► Functions of a complex variable

1056-30-23 **Steve M Anglin, ScM*** (stevemanglin@yahoo.com), 534 N Whisman Rd, Mountain View, CA 94043. *Strong and Weak LFCDs: Local Fractional Complex Derivatives.* Preliminary report.

Fractional complex variables focus on the fractional or non-integer order differential calculus of a complex variable. In fractional calculus, locality can narrow down pieces of a function where there may be better behavior in order to model in an analytic sense, as well as obtain more meaningful physical and/or geometric information. That's where we introduce the concepts of Strong and Weak Local Fractional Complex Derivatives or LFCDs. Strong LFCDs can "maximize" the opportunity that the piece of the function in a localized or local enough area is "well-behaved" (enough). (Received May 12, 2009)

1056-30-147 **Olena Ostapyuk*** (ostapyuk@math.ksu.edu), 138 Cardwell Hall, Manhattan, KS 66506. *Backward-iteration sequences and boundary repelling fixed points in higher dimension.* Preliminary report.

I consider sequences of iterates of an analytic self-map $f$ of the unit ball in $\mathbb{C}^N$. I will show that backward-iteration sequences with bounded hyperbolic step must converge to the boundary, and the limiting points will satisfy some properties, so they will be called boundary repelling fixed points. Conjugations for $f$ near those points will be discussed. (Received August 01, 2009)

1056-30-175 **Rosihan M. Ali*** (rosihan@cs.usm.my), School of Mathematical Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia. *On Janowski starlike functions.*

Let $S^*[A, B]$ be the class consisting of normalized Janowski starlike functions, that is, analytic functions $f$ satisfying the subordination

$$\frac{zf'(z)}{f(z)} \prec \frac{1 + Az}{1 + Bz},$$

where $A, B$ are complex constants, $A \neq B, |B| \leq 1$ and $z$ is in the unit disk $\Delta$. A new class of analytic functions defined by means of convolution is introduced, and sufficient conditions are determined for functions in this class to be Janowski starlike. The results obtained extend earlier known works.

For $A, B, D, E \in [-1, 1]$ and $p$ an analytic function on $\Delta$ with $p(0) = 1$, conditions on $A, B, D$, and $E$ are determined so that $1 + \beta zp'(z) \prec (1 + Dz)/(1 + Ez)$ would imply that $p(z) \prec (1 + Az)/(1 + Bz)$. Similar results are obtained involving the expressions $1 + \beta(zp'(z)/p(z))$ and $1 + \beta(zp'(z)/p^2(z))$. These results are next applied to obtain sufficient conditions for analytic functions to be Janowski starlike.

Finally for functions in the class $S^*[A, B]$, its radius of starlikeness, radius of strong-starlikeness, and radius of parabolic-starlikeness are computed. Consequences of these results will also be discussed. (Received August 11, 2009)

1056-30-514 **See Keong Lee*** (sklee@cs.usm.my), School of Mathematical Sciences, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia. *Subclasses of Meromorphic Functions Associated with Convolution.*

Several subclasses of meromorphic functions in the unit disk are introduced by means of convolution with a given fixed meromorphic funtion. Subjecting each convoluted-derived function in the class to be subordinated to a given normalized convex function with positive real part, these subclaases extend the classical subclassed of meromorphic srtarlikeness, convexity, close-to-convexity, and quasi-convexity. Class relations, as well as inclusion and convolution properties of these subclasses, are investigated. (Received September 11, 2009)

1056-30-601 **Erin R Militzer*** (ermilitzer@gmail.com), 1234 Kastle Road, Lexington, KY 40502. *$L^p$ Rational Approximation in the Complex Plane.* Preliminary report.

Take $X$ to be a compact subset of the complex plane and consider area measure $dA$ on $X$. Let $R(X)$ to be the class of functions that can be uniformly approximated on $X$ by rational functions whose poles lie outside of $X$ and $C(X)$ be the space of all continuous functions on $X$. If $R(X) \neq C(X)$ then there exists $L^p$ bounded point evaluations or (bpe's) for the polynomials for all $p$, $1 < p \leq \infty$. It follows then that $H^p(X, dA) \neq L^p(X, dA)$ where $H^p(X, dA)$ is the closed subspace of $L^p(X, dA)$ that is spanned by the complex analytic polynomials. In contrast, Sinanjan proved in 1966 there exists a set in which $R(X) \neq C(X)$ but nevertheless, $R^p(X, dA) = L^p(X, dA)$, where $R^p(X, dA)$ is the closed subspace of $L^p(X, dA)$ that is spanned by the rational functions having no poles on $X$. We offer an alternative proof to Sinanjan's result. (Received September 14, 2009)

1056-30-810 **Roger W. Barnard*** (roger.w.barnard@ttu.edu), Math. Dept, Texas Tech University, Lubbock, TX 79409. *"Use of computer technology for insight and proof".*

We will discuss and give many examples as to how we were able to use computer software to not only give insight into what geometric and analytical statements should be true as well as finding counterexample to several conjectures, but also to give legitimate, acceptable computer based proofs of a number of theorems in several of our papers. (Received September 17, 2009)

1056-30-957 **Michael J Miller*** (millermj@lemoyne.edu), Dept of Mathematics, Le Moyne College, Syracuse, NY 13214. *On minimal Rolle's domains for complex polynomials.*

Define a subset of the complex plane to be a *Rolle's domain* if it contains (at least) one critical point of every complex polynomial P such that $P(-1) = P(1)$. Define a Rolle's domain to be *minimal* if no proper subset is a Rolle's domain. In this paper, we investigate minimal Rolle's domains. (Received September 18, 2009)

1056-30-1048 **Rich L Stankewitz*** (rstankewitz@bsu.edu), Dept. of Mathematical Sciences, Muncie, IN 47306. *Research in Complex Dynamics using Java Applets.*

Recently many Java applets were created, together with Jim Rolf, primarily for undergraduate students to use to explore complex dynamics phenomena (e.g., chaos, fractals, attracting basins) in conjunction with a new text designed to inspire student driven research (in several areas of complex analysis). Long time researchers can also make use of these applets in their own research and teaching. In this talk we tour just a few of the uses of these applets, touching on several as time permits. Specifically, we discuss the applets designed for investigating real and complex Newton's method, polynomial and exponential iteration, and their corresponding parameter planes. (Received September 20, 2009)

1056-30-1352 **Michael A. Brilleslyper*** (mike.brilleslyper@usafa.edu), Department of Mathematical Sciences, USAF Academy, CO 80840. *Modeling Fluid Flow in the Complex Plane.*

We present a quick tour of several undergraduate-level topics related to modeling ideal fluid flow in regions of the complex plane. We introduce the *FlowTool* applet that allows students to easily explore how the stream lines of the flow are affected by various combinations of sources and sinks. We also use Mathematica to investigate a range of extensions of this standard material to include sources and sinks in the interior of the flow, as well as interval sources. This material forms the content of one chapter of a new proposed text on explorations in complex analysis for undergraduates. (Received September 21, 2009)

1056-30-1625 **James S Rolf*** (jim.rolf@usafa.edu), 1333 Culebra Avenue, Colorado Springs, CO 80903, and **Michael Dorff**. *Applets to Explore Research Topics in Complex Variables.* Preliminary report.

We present Java applets designed to help explore some research questions in complex dynamics, minimal surfaces, flow problems, harmonic univalent mappings, mappings to polygonal domains, and circle packing. These applets accompany a monograph for each topic with both exploratory problems and open problems. In this talk, we will demonstrate some of the applets and show how they can be used to explore research topics in these fields. (Received September 22, 2009)

1056-30-1968 **Ken Stephenson*** (kens@math.utk.edu), Department of Mathematics, University of Tennessee, Knoxville, TN 37996. *Experimental Complex Function Theory via Circle Packing.* Preliminary report.

The Java application "CirclePack" will be used to illustrate experimental complex function theory, conformal mapping, rational functions, finite Blaschke products, harmonic mappings, and conformal curvature flow. (Received September 22, 2009)

1056-30-2128 **Alip Alifu, Maimaiti Mohammed*** (alipm@math), Department of Mathematics and Statistics, York University, 4700 Keele St, Toronto, ON M3J 1P3, Canada. *Poisson Equation with the Robin/Third Boundary Condition.*

The inhomogeneous Robin/third boundary condition with general coefficient for the Poisson equation on the unit disc is studied in terms of holomorphic functions using Fourier analysis. It is shown that against the usual expectations this problem cannot have a unique solution unless the coefficient of the first order term in the boundary condition is a constant. For the case of general coefficient, it is actually a problem with essential singularity in the domain, but still well-posed under proper assumptions and the unique solution can be given explicitly. Our study demonstrates clearly what assumptions about the coefficients of the boundary condition are natural to impose. (Received September 23, 2009)

# 31 ► Potential theory

1056-31-1798 **Lucio M.G Prado*** (lprado@bmcc.cuny), Department of Mathematics, BMCC - The City University of New York, 199 Chambers Street, New York, NY 10007. ***p-Capacity $\mathbb{Z}^n$ and Zeta function.***

The aim of this talk is to present some concepts and techniques from p-potential theory on Riemannian manifolds adapted to *finite* and *infinite graphs*. Namely, we will define p-capacity based on similar concept in continuous settings, which will be used to classify the graphs as p-hyperbolic and p-parabolic. The notions of p-hyperbolicity and p-parabolicity are useful in handling the existence or nonexistence of solutions in the class of p-Dirichlet functions to the Poisson equation for p-Laplacian. In previous talk, we showed how to get explicit formulas for the computation of the p-capacity of the lattices $\mathbb{Z}^n$ and the homogenous trees $T_d$.

In this talk, we will focus specifically on p-hyperbolic lattices $\mathbb{Z}^n$ and highlight the computation of their p-capacity in terms of the Zeta function.

(Received September 22, 2009)

# 32 ► Several complex variables and analytic spaces

1056-32-654 **Alex L Castro*** (alcastro@ucsc.edu), University of California, Santa Cruz, 1156 High Street, Math Dept - 194 Baskin, Santa Cruz, CA 95064, and **Richard Montgomery**. *The Chern-Moser chains of left-invariant CR structures on SU(2) via Fefferman approach.*

We compute the chains associated to the left-invariant CR structures on the three-sphere. These structures are characterized by a single real modulus a. For the standard structure a = 1, the chains are well known and are closed curves. We show that for almost all other values of the modulus a, either two or three types of chains are simultaneously present: closed curves, quasiperiodic curves dense on two-tori, or chains homoclinic be- tween closed curves. For $1 < a < \sqrt{3}$, no curves of the last type occur. A bifurcation occurs at a = $\sqrt{3}$ and from that point on all three types of chains are guaranteed to exist, and exhaust all chains. The method of proof is to use the Fefferman metric characterization of chains, combined with tools from geometric mechanics. The key to the computation is a reduced Hamiltonian system, similar to Euler's rigid body system, and depending on a, which is integrable. (Received September 15, 2009)

1056-32-1230 **C. Affane-Aji*** (affane@tuskegee.edu), Tuskegee University, Tuskegee, AL 36088, and **N. Agarwal** and **N. K. Govil**. *Location of Zeros of Polynomials.*

In this paper, we obtain a result concerning the location of zeros of a polynomial p(z)= a0 +a1z + a2z$^2$ + ... + anz$^n$, where ai's are complex coefficients and z is a complex variable. This result sharpens Cauchy's result, along with some of the other known results which were based on the classical Cauchy's work. Moreover, a MATLAB code is developed to construct polynomials, and compare the bounds obtained by our result with these known results. (Received September 21, 2009)

1056-32-1285 **Michael C Fulkerson*** (mfulkerson@uco.edu), 100 N. University Drive, Campus Box 129, Edmond, OK 73034. *A residual radial limit zero set.*

We construct a nonconstant holomorphic function on the unit ball in $\mathbb{C}^n$ having radial limit zero at each point of a certain residual subset of the unit sphere. (Received September 21, 2009)

1056-32-2100 **David G. Wagner*** (dgwagner@math.uwaterloo.ca), C&O Department, University of Waterloo, Waterloo, ON N2M 4S7, Canada. *Multivariate stable polynomials: theory and applications.*

Univariate polynomials with only real roots – while special – do occur frequently enough that their properties can lead to interesting conclusions in diverse areas. Due largely to the work of two young mathematicians, Julius Borcea and Petter Brändén, a very successful multivariate generalization of this method has recently been developed. The first part of this paper surveys some of the main results of this theory of "multivariate stable" polynomials – the most central of these results is the characterization of linear transformations preserving stability. The second part of the paper presents various applications of the theory in complex analysis, statistical mechanics, probability, combinatorics, and matrix theory. (Received September 23, 2009)

# 33 ► *Special functions*

1056-33-369 **Mohsen Razzaghi*** (razzaghi@math.msstate.edu), Department of Mathematics & Statistics, Mississippi State University, Mississippi State, MS 39762. *Solution for nonlinear initial-value problems via orthogonal functions.*

Orthogonal functions have received considerable attention in dealing with various problems of dynamic systems. The main characteristic of this technique is that it reduces these problems to those of solving a system of algebraic equations, thus greatly simplifying the problem. The approach is based on converting the underlying differential equations into an integral equation through integration, approximating various signals involved in the equation by truncated orthogonal series, and using the operational matrix of integration to eliminate the integral operations. In this talk, a numerical method for solving the nonlinear ordinary differential equations with initial conditions is proposed. The approach is based upon hybrid function approximations. The properties of hybrid functions, which consist of block-pulse and Legendre polynomials, are presented. The associated operational matrix of integration is then utilized to reduce the solution of the initial-value problems to the solution of a system of algebraic equations. The method is easy to implement and computationally very attractive. Applications are demonstrated through an illustrative example. (Received September 02, 2009)

1056-33-899 **Jemal Emina Gishe*** (jemal.gishe@wku.edu), Western Kentucky University, Department of Mathematics, Bowling Green, KY 42101-1078, and **Mourad E.H. Ismail** (ismail@math.ucf.edu), University of Central Florida, Department of Mathematics, Orlando, FL 32816. *Resultants of Chebyshev Polynomials.*

Recently, K.Dillcher and K.B.Stolarsky used algebraic methods to evaluate the resultant of two linear combinations of Chebyshev polynomials of the second kind. In this paper we give an alternative method of computing the same resultant and resultants of more general combinations of Chebyshev polynomials of the second kind. We also consider resultants of linear combinations of Chebyshev polynomials of the first kind. (Received September 18, 2009)

1056-33-922 **Alexander Rozenblyum*** (ARozenblyum@CityTech.cuny.edu), Mathematics Department, New York City College of Technology, CUNY, 300 Jay Street, Brooklyn, NY 11201. *Representations of quantum group $U_q(so(n))$ and $q$-orthogonal polynomials.*

We study the spectrum and eigenvectors of infinitesimal operators (generators) of irreducible representations of the quantum group $U_q(so(n))$ which is the $q$-deformation of the universal enveloping algebra $U(so(n))$. Explicit formulas for the eigenvalues (including multiplicities) of the generators of representations are obtained. Corresponding eigenvectors are described in terms of certain types of orthogonal polynomials in many discrete variables. These polynomials may be considered as $q$-analogs of classical Krawtchouk and dual Hahn polynomials. (Received September 18, 2009)

# 34 ► Ordinary differential equations

1056-34-27 **Johnny Henderson*** (Johnny_Henderson@baylor.edu), Department of Mathematics, Baylor University, Waco, TX 76798-7328. *Eigenvalue intervals for a system of generalized second order three point nonlinear boundary value problems on a time scale.*

Intervals of eigenvalues yielding positive solutions for a system of generalized second order three point nonlinear boundary value problems on a time scale are obtained. The Guo-Krasnoselskii fixed point theorem for positive operators on a cone is applied. (Received June 05, 2009)

1056-34-125 **Marion Weedermann*** (mweederm@dom.edu), Dominican University, 7900 W Division St, River Forest, IL 60305. *Qualitative Analysis of Models for Anaerobic Digestion including Syntrophic Interactions.* Preliminary report.

This study addresses two stages of anaerobic digestion, acetogenesis and methanization. First, we consider a first basic model that includes two types of bacteria and two nutrients. The nutrient for one organism is supplied to a well-stirred feed vessel. The growth of this species is accompanied by the formation of an intermediate product that is growth-limiting for the second organism. However, excess of the intermediate product is also growth inhibiting to the second organism. The model is then modified to study the impact of (i) an externally introduced toxin and (ii) a dynamically allocated toxin (syntrophy). In either case only one type of micro-organism is affected by the toxin while the second organism breaks down the nutrient.

We give conditions that ensure local and global stability for the various equilibria, and show that the inhibition may cause bistabilities of two equilibria. In the presence of a toxin there are additional possibilities for bistabilities including that of a periodic orbit and an interior equilibrium. (Received July 28, 2009)

1056-34-144 **Ericka Mochan*** (locomochan@yahoo.com), Department of Biomedical Engineering, 1215 Wilbraham Road, Western New England College, Springfield, MA 01119, and **C Davis Buenger** (davis.buenger@rice.edu), Math Department, 6100 S. Main St, Rice University, Houston, TX 77005-1892. *Coexistence of Stable ECM Solutions in the Lang-Kobayashi System.*

The Lang-Kobayashi system of delay differential equations describes the behavior of the complex electric field $\varepsilon$ and the inversion $N$ inside an external cavity semiconductor laser. This system has a family of special periodic solutions known as External Cavity Modes (ECMs). It is well known that these ECM solutions appear through saddle-node bifurcations, then lose stability through a Hopf bifurcation before new ECM solutions are born through a secondary saddle-node bifurcation. Employing analytical and numerical techniques, we show that for certain short external cavity lasers the loss of stability happens only after the secondary saddle-node bifurcations, which means that stable ECM solutions can coexist in these systems. We also investigate the basins of these ECM attractors. (Received August 02, 2009)

1056-34-330 **Mihaela Cristina Drignei*** (mdrignei@allegheny.edu), Mathematics Department, Allegheny College, Meadville, PA 16335. *An inverse Sturm-Liouville problem using three spectra.* Preliminary report.

We investigate the numerical constructibility of the classical solution to the inverse Sturm-Liouville problem using three Dirichlet spectra. This inverse spectral problem corresponds to the practical situation of recovering the density of an elastic string from its three sets of frequencies of oscillation: the first set corresponds to the vibration of the entire string when the end points are fixed; the second and third sets correspond respectively to the independent vibration of the left and right parts of the string when, in addition to the end points, an interior node of the string is fixed. (Received August 29, 2009)

1056-34-334 **Jonathan Graf*** (jgraf1@students.towson.edu), 4300 E. Joppa Rd, Baltimore, MD 21236, and **Olga Stulov** and **Jim Sochacki**. *What Moves You: Using Legs for Vehicular Transportation.*

Most vehicles are transported by the rotation of wheels. The Department of Mathematics and Statistics and Department of Engineering at James Madison University are interested in developing vehicles that will be driven by the motion of legs rather than wheels. In this talk we discuss the motion of five different legs: first, we derive the equations of motion for each leg; second, we calculate the equations for velocity, acceleration, energy and power; third, we optimize the motion by minimizing energies and forces. In order to obtain these results, we developed a differential equation, solved it using the Parker-Sochacki Method and reached the optimal solution using Maple's minimization package. (Received August 30, 2009)

1056-34-350 **Jerome Goddard II*** (jg440@msstate.edu), P.O.Drawer MA, Mississippi State, MS 39762, **EunKyoung Lee** (eunkyoung165@gmail.com), Department of Mathematics, Pusan National University, Pusan, South Korea, and **Ratnasingham Shivaji** (shivaji@ra.msstate.edu), P.O.Drawer MA, Mississippi State, MS 39762. *On the existence of a double S-shaped bifurcation curve.*

We study the positive solutions to boundary value problems of the form

$$\begin{aligned} -u'' - \frac{n-1}{r}u' &= \lambda f(u); \quad \Omega \\ -\alpha(x,u)u'(r) + [1-\alpha(x,u)]u(r) &= 0; \quad |x| = R_1 \\ \alpha(x,u)u'(r) + [1-\alpha(x,u)]u(r) &= 0; \quad |x| = R_2 \end{aligned}$$

where $\Omega = \{x | R_1 < |x| < R_2\}$ is an annulus in $\mathbb{R}^n$ with $n \geq 1$, $\lambda$ is a positive parameter, $f : [0,\infty) \longrightarrow (0,\infty)$ is a smooth function which is sublinear at $\infty$, and $\alpha(x,u) : \Omega \times \mathbb{R} \longrightarrow [0,1]$ is a non-decreasing smooth function. In particular, we discuss the existence of at least two positive radial solutions for $\lambda \gg 1$. Further, we discuss the existence of a double S-shaped bifurcation curve when $n = 1$, $\Omega = (0,1)$, and $f(s) = e^{\frac{\beta s}{\beta + s}}$ with $\beta \gg 1$. (Received September 01, 2009)

1056-34-388 **Adnan H Sabuwala*** (asabuwala@csufresno.edu), 5245 N Backer Ave, M/S PB 108, Fresno, CA 93722. *Particular Solution to the Euler-Cauchy Equation: A Novel Approach.* Preliminary report.

The Euler-Cauchy differential equation is one of the first, and simplest, forms of a higher order non-constant coefficient ordinary differential equation that is encountered in an undergraduate differential equations course. For a non-homogeneous Euler-Cauchy equation, the particular solution is typically determined by either using the method of variation of parameters or transforming the equation to a constant-coefficient equation and applying the method of undetermined coefficients. In this talk, we demonstrate the surprising form of the particular solution for the most general $n^{th}$ order Euler-Cauchy equation when the non-homogeneity is a polynomial. In addition, a formula that can be used to compute the unknown coefficients in the form of the particular solution will be presented. (Received September 03, 2009)

1056-34-405 **Gro Hovhannisyan***, 6000 Frank avenue NW, North Canton, OH 44720. *Asymptotic Behavior of Linear Dynamic Systems on Time Scales.* Preliminary report.

We introduce characteristic functionals for dynamic systems on time scales and generalize Hartman-Wintner's theorems about asymptotic solutions with the error estimates for 2D dynamic systems on a time scale. (Received September 04, 2009)

1056-34-420 **Dorian Wilkerson*** (rohrs@math.gatech.edu), Physics Department, Box 1744, Atlanta, GA 30314. *Analysis of a Truly Nonlinear Oscillator.*

We investigate the mathematical properties of solutions to the truly nonlinear (TNL) oscillator differential equation

$$\ddot{x} + x^{1/3} = 0. \tag{$*$}$$

In particular, we demonstrate that all solutions are periodic. Two procedures, the methods of harmonic balance and iteration, are used to construct approximations to the periodic solutions. A measure of the accuracy of the approximations is provided by calculating the percentage errors in the associated angular frequencies. (Received September 05, 2009)

1056-34-425 **Imran Naeem*** (inqau@yahoo.com), Opposite sector U, DHA Lahore cantt, Lahore, Punjab 54792, Pakistan, **Fazal Mahomed** (Fazal.Mahomed@wits.ac.za), School of CAM, University of the, Witwatersrand, Johannesburg, Gauetng 2050, South Africa, and **R Naz** (rehananaz_qau@yahoo.com), LUMS, Pakistan, Lahore, Punjab 54792, Pakistan. *First Integrals for Systems via Complex Partial Lagrangians.*

The partial Noether operators and partial Euler-Lagrange equations are developed for a single as well as for a system of kth-order ordinary differential equations (ODEs) in the complex domain with the help of complex partial Lagrangians. A complex partial Noether theorem is deduced and the formula which provides the complex rst integral is equivalent to the complex Noether integral. These complex partial Noether operators, in general, are not complex symmetries of systems of complex ODEs and they are not closed. The theorems are provided which give the condition of closure and when they become complex symmetry generators is also stated. The results obtained in the complex domain are decomposed into the real domain for system of m second-order complex ODEs with m dependent variables. The complex partial Lagrangian splits into two real partial Lagarangians which satisfy partial Euler-Lagrange equations in the real domain. Each complex partial Noether operator yields two real partial Noether operators of the real partial Lagrangians. The complex first integrals result in two real rst integrals for the system of ODEs split in the real domain. (Received September 06, 2009)

1056-34-433 **Camilo Sanabria*** (csanabria_malagon@gc.cuny.edu), Mathematics Ph.D. Program, The CUNY Graduate Center, 365 Fifth Avenue, Room 4208, New York, NY 10016-4309. *Symmetries of Standard Equations.*

We concentrate our attention on Linear Differential Equations over Compact Riemann surfaces and we address the problem of descent. An early result on this setting is Klein's Theorem which states that any second order linear differential equation with algebraic solutions is the pullback of a standard hypergeometric equation. M. Berkenbosch, M. van Hoeij and J.A. Weil introduced the concept of standard equation leading, on one hand, to Berkenbosch's generalization of Klein's theorem to the third order; and, on the other, to a very efficient algorithm, improving Kovacic's, that makes the above-mentioned pullback explicit. On their turn, standard equations may be pullbacks of other equations, deepening further the descent. In this talk I will expose how descent conditions for standard equations can be obtained through the outer-automorphisms of their Galois Group. The key-tool to achieve this last descent will be the study of the symmetries of the equation. Symmetries of equations are easy to define in terms of connections: under the well know correspondence between linear differential equations and meromorphic vector bundles with connection, a symmetry of the equation is an automorphism of the underlying Rieman surface lifting to a parallel morphism on the vector bundle. (Received September 07, 2009)

1056-34-448 **Elif Demirci*** (edemirci@science.ankara.edu.tr), Ankara University Department of Mathematics, Besevler, Ankara, 06100, and **Nuri Ozalp**. *On Stability of Solutions of Fractional Order SEIR Epidemic Model with Vertical Transmission.* Preliminary report.

Fractional order differential equations are related to systems with memory effect which is important in most of the biological systems. In this work, a fractional order SEIR epidemic model with vertical transmission is considered. Existence, uniqueness and positivity of solutions are given. The stability of equilibrium points is studied. An example is given where the equilibrium point is nonstable in integer order system but locally asymptotically stable in fractional order counterpart. (Received September 10, 2009)

1056-34-492 **Ravi P. Agarwal** and **Fatma Karakoc*** (karakoc@science.ankara.edu.tr), Department of Mathematics, Faculty of Science, Ankara University, 06100 Ankara, Turkey. *Oscillation of Impulsive Partial Difference Equations with Continuous Variables.*

In this talk, a class of linear impulsive partial difference equations with continuous variables is considered. We establish a difference inequality without impulses and use it to obtain various sufficient conditions for the oscillation of solutions. (Received September 10, 2009)

1056-34-496 **John V. Matthews*** (Matt-Matthews@utc.edu), 415 EMCS Building, Dept 6956, 615 McCallie Ave, Chattanooga, TN 37403, and **Boris P. Belinskiy**. *Analysis and Numerical Solution of a Non-local ODE Motivated by Flutter.*

Motivated by the problem of aeroelastic instability, we study three connected Sturm-Liouville problems for nonlinear ordinary differential equations. A non-local term proposed by engineers is incorporated into one of these problems, and its role proves essential. Analysis for all three problems is given along with asymptotic results. The spectra and corresponding eigenfunctions are revealed numerically through a modification of simple shooting. (Received September 10, 2009)

1056-34-638 **Primitivo B. Acosta-Humánez*** (primi@ima.usergioarboleda.edu.co), IMA, Instituto de Matemáticas y sus Aplicaciones, Universidad Sergio Arboleda, Bogota & Santa Marta, Colombia. *Differential Galois Theory and Darboux Transformations.* Preliminary report.

Darboux transformation is considered the starting point of Supersymmetric Quantum Mechanics for $n = 2$. Today such transformation is very used in different subjects as integrability of partial differential equations.

In this talk we present a Galoisian meaning to Darboux transformations. In particular, we write the Darboux transformation in the formalism of differential Galois theory showing that such transformation is iso-Galoisian (the differential Galois group is preserved) and the eigenrings are isomorphic. Finally, we write the Darboux transformation in matricial formalism for some $2 \times 2$ and $3 \times 3$ systems giving illustrative examples.

This is a joint work with Juan Morales-Ruiz, Moulay Barkatou and Jacques-Arthur Weil. (Received September 15, 2009)

1056-34-720 **Dmitry Altshuller*** (altshuller@ieee.org), Crane Aerospace & Electronics, 3000 Winona Ave, Burbank, CA 91510. *Frequency-Domain Criteria for Robust Stability for a Class of Linear Time-Periodic Systems.*

The paper considers the problem of robust stability of a linear system

$$x'(t) = Ax(t) + P(t)x(t), \tag{1}$$

where $x(t) \in \mathbb{R}^m$ and the matrix $P(t)$ is a direct product of a constant and a time-periodic vector.

Robust stability means that for all solutions $x(t)$ of (1), $x(\cdot) \in L_2(0;\infty)$ and, furthermore, there exists a constant $\lambda$, same for all solutions, such that $\|x(\cdot)\| \le \lambda \left\|e^{At}x(0)\right\|$, with the double bars denoting the usual Euclidean norm in $L^2[0;+\infty]$.

The main result is given in terms of the frequency response of the constant part, which makes it applicable to cases when matrix $P(t)$ conatins uncertainty. It is then used to derive simple stability criteria for some special cases, including the Hill's and Mathieu's equations. Comparison with classical results concludes the paper. (Received September 22, 2009)

1056-34-777 **Adam Fletcher Childers*** (childers@roanoke.edu), 1906 Arlington Rd., Roanoke, VA 24015. *Bounded Error Parameter Identification and the Design of Experiments for Models Described by Ordinary Differential Equations.* Preliminary report.

In this paper we focus on the problem identifying parameters and designing experiments for non-linear dynamical systems in the case when the number of data samples is too small for standard statistical analysis. The models are described by ordinary differential equations with bounded errors. When the number of data samples is very small, standard parameter validation methods are not applicable because classical statistical asymptotic theory relies on the behavior of the estimated parameter as the number of samples grows large. We present a new computational method for parameter identification and show how it can be applied to the design of experiments problem for a specific class of models. Although the assumptions lead to a restricted class of models, the new parameter identification algorithm is computationally efficient for this class of problems. We introduce the basic ideas, provide some heretical results needed for the convergence of the parameter identification method and present numerical examples to illustrate how it can be applied to designing experiments. (Received September 17, 2009)

1056-34-851 **Mehmet Unal*** (munal@bahcesehir.edu.tr), Faculty of Engineering, Ciragan Cad. No 4-6, Besiktas, 34353 Istanbul, Turkey. *Integral inequalities for certain nonlinear systems on time scales.*

we obtain integral inequalities for certain nonlinear systems on an arbitrary time scale $\mathbb{T}$ by using elementary time scale calculus. These inequalities enable us to obtain a criterion of disconjugacy for such systems. Special cases of our results contain the classical Lyapunov inequality for both differential and difference equations. (Received September 18, 2009)

1056-34-862 **Zhivko S. Athanassov*** (zhivko@math.bas.bg), G. Bonchev Str. 8, 1113 Sofia, Bulgaria. *Asymptotically Autonomous Differential Inclusions.* Preliminary report.

We discuss the asymptotic behaviour of solutions of asymptotically autonomous differential inclusions in relation to the behaviour of solutions of the associated limiting inclusions. We do this using continous selections. The results presented extend the already classical results of L.Markus, Z.Opial, T.Yoshizawa, and A.Strauss and J.Yorke for asymptotically autonomous ordinary differential equations. (Received September 18, 2009)

1056-34-873 **Peng Feng*** (pfeng@fgcu.edu), 10501 FGCU Blvd. S., Fort Myers, FL 33965. *Dynamics of a segmentation clock model with discrete and distributed delays.*

In this talk, we study the effects of time delays on the dynamics of a segmentation clock model with both discrete and distributed delays. Two cases are considered. The first case corresponds to the model with only distributed delay. The second case involves both discrete and distributed delay. More precisely, we study the following model:

$$\frac{dp}{dt} = am(t-\tau_p) - bp(t),$$

$$\frac{dm}{dt} = \int_{-\infty}^{t} g(t-s)f(p(s))ds - cm(t).$$

Local stability analysis is carried out for all cases. Numerical simulations are also performed to illustrate the results. (Received September 18, 2009)

1056-34-995 **gaston m n'guerekata*** (Gaston.N'Guerekata@morgan.edu), 1700 East Cold Spring Lane, Baltimore, MD 21251. *Circular spectrum and bounded solutions of periodic evolution equations in Banach spaces.*

We study the existence and uniqueness of bounded solutions of periodic evolution equations of the form $u' = A(t)u + \epsilon H(t,u) + f(t)$ in a Banach space $X$ where $A(t)$ is, in general, an unbounded operator depending 1-periodically in $t$, $H$ is 1-periodic in $t$, $\epsilon$ is small, and $f$ is a bounded continuous function. We propose a new approach to the spectral theory of functions via the concept of "circular spectrum" and then apply it to study the linear equation $u' = A(t)u + f(t)$ with general conditions on $f$. For small $\epsilon$, we show that the perturbed equation inherits some properties of the unperturbed one. The main resulst extend recent results in the direction, saying that if the unitary spectrum of the monodromy operator does not intersect the circular spectrum of $f$, then the evolution equation has a unique mild solution with its spectrum contained in the circular spectrum of $f$ (Received September 19, 2009)

1056-34-1144 **Claude Mitschi*** (mitschi@math.u-strasbg.fr) and **Michael F. Singer**. *The Galois group of monodromy evolving deformations.*

Isomonodromic families of regular singular differential equations over $\mathbb{C}(x)$ are characterized by the fact that their parameterized differential Galois group is conjugate to a linear algebraic group over $\mathbb{C}$. We will describe properties of this differential group that reflect a special type of monodromy evolving deformations of Fuchsian differential equations. (Received September 21, 2009)

1056-34-1149 **Toka Diagana*** (tokadiag@gmail.com), 2441 6th Street NW, Washington, DC 20059. *Existence of pseudo almost automorphic solutions to some classes of nonautonomous partial evolution equations.* Preliminary report.

In this talk we will discuss the existence of pseudo almost automorphic solutions to some classes of nonautonomous partial evolution equations on a Banach space. Using intermediate space techniques, some existence results will be presented. A few examples will also be given to illustrate the main result of the talk. (Received September 21, 2009)

1056-34-1174 **J. Regan Beckham*** (rbeckham@uttyler.edu), Department of Mathematics, 3900 University Blvd., Tyler, TX 75799. *Modeling of Electrostatic-Elastic Membrane Systems Motivated by MEMS Devices.*

Electrostatic-elastic membrane systems are used in microelectromechanicalsystems (MEMS) devices as a means of locomotion. We consider a number of variants to the standard capacitive model. In each case a mathematical model is formulated, analyzed, and solved numerically. Due to the scaling properties of the electric field, it is possible to perform macro-scale experiments to compare with results obtained from the mathematical model. (Received September 21, 2009)

1056-34-1221 **Billur Kaymakcalan*** (billur@georgiasouthern.edu), **Ravi P. Agarwal**, **Said R. Grace** and **Wichuta Sae-jie**. *Oscillation criteria for some types of second order nonlinear dynamic equations.*

We investigate the oscillatory behavior of second order nonlinear dynamic equations of the form $(a(x^\Delta)^\alpha)^\Delta(t) + q(t)x^\beta(t) = 0$, their forced and forced-perturbed extensions, as well as similar behavior of equations of the type $(a(t)(x^\Delta(t))^\alpha)^\Delta + f(t, x^\sigma(t)) = 0$, on an arbitrary time scale $\mathbb{T}$, where $\alpha$ and $\beta$ are ratios of positive odd integers, $a$ and $q$ are real-valued, positive, rd-continuous functions on $\mathbb{T}$ and $f : [t_0, \infty) \times \mathbb{R} \to \mathbb{R}$ is continuous, $sign\, f(t,x) = sign\, x$, with $f(t,x)$ being non-decreasing in $x$ for each fixed $t \geq t_0$. (Received September 21, 2009)

1056-34-1229 **Menaka B Navaratna*** (mnavarat@fgcu.edu), 10501 FGCU Blvd, S., Fort Myers, FL 33965, and **Channa N Navaratna**. *Mathematical analysis of synchronization of pacemaker cells in mammals.*

In mammals the main pacemaker cells are located in suprachiasmatic nucleus (SCN). Study focuses on the possible connection topologies of neurons and their effect on synchronization. We employ Achermann and Kunz (1999) model to study the problem of interpreting synchronization in the SCN network from a dynamical systems viewpoint. The proportion of local or nearest neighbor neuronal connections and global or long distance connections are varied in the SCN, and compared time elapsed before synchronization is established. In conjunction with our previous finding that completely interconnected global networks resynchronize, these results suggest the possibility that the SCN topology is a "small world" network. (Received September 21, 2009)

1056-34-1269 **Joan Hoffacker*** (johoff@clemon.edu), Department of Mathematical Sciences, O-110 Martin Hall, Clemson, SC 29634-0975. *Implications of time scales to spraying mosquitoes for West Nile prevention.*

The purpose of this paper is to investigate whether this is the most effective control strategy because past mathematical models assumed discrete behavior that is modeled by difference equations for a single summer season, was most important to the virus's development cycle. (Received September 21, 2009)

1056-34-1368 **Benjamin Steinhurst*** (steinhurst@math.uconn.edu), 196 Auditorium Rd, Storrs, CT 06269. *Dirichlet forms on Laakso Spaces.*

We show how to construct Laakso spaces as projective limits of quantum graphs. Then using this construction we put a Dirichlet form on the Laakso spaces using a Laplacian corresponding very closely to the usual Laplacian (second differentiation). This Laplacian has a well understood spectrum which will also be given. (Received September 21, 2009)

1056-34-1434 **Seenith Sivasundaram*** (seenithi@gmail.com), 104 Snow Goose CT, Daytona Beach, FL 32119. *Existence of solutions for impulsive integral boundary value problems of fractional order.*

In this paper, we prove some existence results for a boundary value problem of nonlinear impulsive differential equations of fractional-order q in (1,2]with integral boundary conditions by applying the contraction mapping principle and Krasnoselskii's fixed point theorem. (Received September 21, 2009)

1056-34-1456 **Bonita A Lawrence*** (lawrence@marshall.edu), Marshall University, One John Marshall Drive, Huntington, WV 25755, and **Anna Mummert** (mummerta@marshall.edu), Marshall University, One John Marshall Drive, Huntington, WV 25755. *Model for Antibiotic Resistant Bacteria in a River.* Preliminary report.

Antibiotic resistance is a growing threat to the state of modern medicine. Better understanding of the transfer of the antibiotic resistant gene between microorganisms is crucial for the safety and prosperity of humankind. We propose a deterministic dynamical model, that is, a system of ordinary differential equations, for antibiotic resistant bacteria in rivers. We consider both the indigenous river bacteria and the bacteria entering the river from the shore. (Received September 22, 2009)

1056-34-1665 **Faina Berezovskaya*** (fberezovskaya@howard.edu), 6-th str., Washington, DC 20059. *Models of two-patch predator-prey community dynamics.*

We explore the population dynamics of two-patch communities, prey – predator-prey and two predator-prey systems. The patch interactions are mediated by Allee-type prey populations; differences in prey abundance are the drivers of prey dispersal. The considering models are 3D- and 4D- ODE systems depending on parameters. The goal consists of the description and interpretations of the bifurcation diagrams of the models. In fact, we showed that considering communities can coexist with such parameter values for which a separate system get extinction and had analyzed the modes of coexistence.The 3D-model shows that as dispersal between habitats increase, the community experiences transitions from extinction, to stable oscillatory co-existence, to non-oscillatory co-existence with the outcomes depending on initial values. The possibility of bi- and tri- stability all leading to distinct outcomes is discussed. The 4D-model demonstrates two types of 4D-stable oscillations for the same parameter values from wide range domains. With parameter changing, oscillations of the first type disappear by an unlimited growth of period whereas those of the second type disappear chaotically. Note, that 4D-model demonstrates all stable regimes of the 3D- model at corresponding initial values. (Received September 22, 2009)

1056-34-1721 **Sigrun Bodine*** (sbodine@ups.edu), 1500 N Warner, Tacoma, WA 98416, and **D.A. Lutz**. *On second order nonoscillatory scalar linear dynamic equations on time scales.* Preliminary report.

We are interested in the asymptotic behavior of solutions of

$$[r(t)x^{\Delta}]^{\Delta} + f(t)x^{\sigma} = 0, \qquad t \geq t_0, \quad t \in \mathbb{T},$$

as a perturbation of

$$[r(t)y^{\Delta}]^{\Delta} + g(t)y^{\sigma} = 0, \qquad t \geq t_0, \quad t \in \mathbb{T},$$

which is assumed to be nonoscillatory at infinity (here $r(t) > 0$).

This problem was considered in the context of differential equations by a variety of mathematicians including Hartman and Wintner, Trench, Šimša, Chen, and Chernyavskaya and Shuster. Recently, first results on time scales were established by Bohner and Stević.

In our talk, we offer a new approach to this problem. Working in a matrix setting, we use preliminary and so-called conditioning transformations to bring the system in the form

$$z^{\Delta} = [\Lambda(t) + R(t)]z,$$

where the diagonal matrix $\Lambda$ and the perturbation $R$ satisfy the conditions of Levinson's Fundamental Theorem on time scales as established by Bohner and Lutz.

This is a joint work with Professor Donald A. Lutz from San Diego State University. (Received September 22, 2009)

1056-34-1838 **Elvan Akin-Bohner*** (akine@mst.edu), Missouri University of Science and Technology, 400 W 12th Street, Rolla, MO 65409. *Oscillation criteria for second order dynamic inclusions.*

We establish some oscillation criteria for second order dynamic inclusions. (Received September 22, 2009)

1056-34-1852 **Antonio Mastroberardino*** (axm62@psu.edu), Penn State Erie, The Behrend College, School of Science, Erie, PA 16563, and **Joseph E Paullet**. *Analysis of radial stagnation flow toward a stretching cylinder.*

We investigate the nonlinear boundary value problem that is derived from a similarity transformation of the Navier-Stokes equations governing fluid flow toward a stretching permeable cylinder. Existence of a solution is proven for all values of the Reynolds number and for both suction and injection, and uniqueness results are obtained in the case of a monotonically decreasing solution. A priori bounds on the skin friction coefficient are also obtained. (Received September 22, 2009)

1056-34-2043 **Ben T Nohara*** (drben@tcu.ac.jp), 1-28-1, Tamazutsumi, Setagaya-ku, Tokyo, and **A Arimoto**. *Parameter Dependency on the Period of the Solutions for the Duffing Equation with Double-well Potential.* Preliminary report.

In this talk, we discuss the periodic solutions of the Duffing equation $\frac{d^2u}{dt^2} - au + bu^3 = 0$, where $u = u(t) : R \to R, t \geq 0, a, b > 0$, which has cubic non-linearity and a double-well potential. This equation is of importance in the mechanical engineering at discussing the nonlinearity as well as the dynamical system.

First, we show the phase portraite for understanding overall phenomina and present that all solutions can be written in the analytic forms using Jacobi elliptic functions. Solutions formulae depend on the potential, which is naturally induced from the equation. Also we show the exact period of the solutions using the complete elliptic integral of the first kind. Then we analyze the parameter-dependency "a" or "b" in the equation on the obtained periodic solutions. We show that there exists a maximum period when a parameter "a" varies. Also we present that the solution of the zero limitation of the parameter does not match the one of the original equation with zero paramenter.

In the lecture the numerical simulations are also presented. (Received September 23, 2009)

# 35 ► *Partial differential equations*

1056-35-24 **Alexander Kozhevnikov*** (kogevn@math.haifa.ac.il), Dept. of Math., Univ. of Haifa, 31905 Haifa, Israel. *On Solvability of Initial-Boundary Value Problems for Multi-Weighted Parabolic Systems.* Preliminary report.

The most known parabolic equation is the heat or diffusion equation. For this equation t-differentiation is comparable in strength to differentiating 2 times with respect to the spacial coordinates. This means that the t-differentiation has weight 2, whereas spacial differentiation has weight 1. Similarly for general parabolic operators, the t-differentiation has weight 2b with some natural b, whereas spacial differentiation has weight 1. I.G. Petrovskii 1938, T. Shirota 1955 and V. Solonnikov 1965 introduced successively more and more general definitions of parabolic systems (see e.g. known monographs by A. Friedman 1964, S.D. Eidelman 1969, O.A. Ladyzhenskaja, V.A. Solonnikov, N.N. Ural'ceva 1968, S.D. Eidelman, N.V. Zhitarashu 1998 and references there). In spite of the fact that the entries of matrix operator have different orders with respect to the spacial variables, the t-differentiation has a constant weight 2b. Therefore all these systems can be called single-weighted. The aim of the presentation is to formulate a more general definition of multi-weighted parabolic systems as well as to state for these systems solvability of the initial-boundary value problems in appropriate Sobolev-type spaces. (Received May 29, 2009)

1056-35-85 **Xuming Xie*** (xuming.xie@morgan.edu), Department of Mathematics, Morgan State Univerity, Baltimore, MD 21251. *Well-posedness and regularity of one phase Hele-Shaw bubble problem.* Preliminary report.

We study an initial value problem for a Hele-Shaw problem with and without surface tension. The initial value problem is derived from one-phase model based on complex variables method. If the initial data is in Sobolev space, we first prove that unique local solution exists in proper Sobolev space using energy methods. Then we also discuss the higher regularity of the solution. (Received July 24, 2009)

1056-35-93 **Silvia Jimenez*** (sjimenez@math.lsu.edu), 4083 Burbank Dr, Apt. 3, Baton Rouge, LA 70808, and **Robert Lipton**. *Correctors and Field Fluctuations for the $p_\epsilon(x)$-Laplacian with Rough Exponents.*

Properties of local fields inside mixtures of two nonlinear power law materials are studied. This simple constitutive model is frequently used to describe several phenomena ranging from plasticity to optical nonlinearities in dielectric media. This work addresses a prototypical problem in the scalar setting.

We provide the corrector theory for the strong approximation of fields inside composites made from power law materials. These results are applied to deliver new multiscale tools for bounding the local singularity strength inside micro-structured media in terms of the macroscopic applied fields. (Received September 07, 2009)

1056-35-190 **Bonnie C Jacob***, Dept of Mathematical Sciences, Martin Hall, Clemson University, Clemson, SC 29630. *Maximizing Distinguishability in Optical Tomography through Selection of an Optimal Source: Function Spaces and Inner Products.*

Optical tomography is an imaging technique that reconstructs the optical properties of highly scattering media using near-infrared light. While the benefits of optical tomography could be of tremendous value in areas such as breast cancer detection because of its non-invasive nature, the ill-posedness of the problem means that good reconstructions remain illusive.

We combat the ill-posedness of optical tomography by seeking a source $f$ that will maximize distinguishability of the optical parameters, allowing us to make the problem as well-posed as possible. We investigate the influence of different function spaces and their corresponding inner products on the selection of the optimal source for the diffusion approximation to the radiative transfer equation. The weak formulation corresponding to the diffusion equation does not lead to a self-adjoint operator; we therefore must compute the adjoint for all eight pairs of inner products. We use the power method to numerically determine the optimal source for each function space pair, and compare the solutions. (Received August 13, 2009)

1056-35-235 **Andrea Catalina Rubiano*** (arubiano@purdue.edu), 203 Montifiore St, Apt 309, Lafayette, IN 47905. *On stable states in a coupled energetic model for incompressible nematic elastomers.*

We investigate an energetic model for incompressible nematic elastomers that combines the energy density developed by Bladon, Warner and Terenjtev with the classical energy density from Landau - de Gennes theory for uniaxial nematic liquid crystals. A unit-length molecular director of the nematic elastomer and an incompressible deformation are the unknown functions, minimizers of the coupled energy. Based on physical experiments, we consider the problem of a thin domain in $R^3$ clamped on its sides that is being stretched perpendicular to its original director. In contrast to previous mathematical works in this field, the molecular director is not assumed to be constant throughout the domain. After establishing a suitable energetic model for this situation, we prove lower semi-continuity of the energy and the existence of minimizers. Keeping the restriction of incompressibility on the deformation and unit length of the director, we derive weak Euler Lagrange equations satisfied by the minimizers. Additionally, we consider the reduction of the model to a 2-dimensional one and deduce existence results for non-convex energy densities involving a penalization on the volume constraint. In this case we also find weak Euler-Lagrange equations and prove a partial regularity result. (Received September 10, 2009)

1056-35-241 **Myles D Baker*** (myles_baker@baylor.edu), Myles Baker c/o Qin Sheng, Department of Mathematics - Baylor University, One Bear Place #97328, Waco, TX 76798-7328, and **Sarah R Farell** (sf457@bard.edu), Bard College, 30 Campus Rd., Annandale-On-Hudson, NY 12504. *Approximating Convection Dominated Diffusion PDEs Using an Adaptively Weighted Least Squares Finite Element Approach.* Preliminary report.

PDEs of the convection-diffusion-reaction form have unique exact solutions that are very difficult to find, and numerical approaches to those solutions give rise to error as a byproduct of approximation. Due to the nature of computational methods for solving PDEs, cost-efficiency is important; boundary layers of elliptical PDEs cause solutions of the least-squares approach to be overly smoothed and our goal is to improve the least-squares method by using an adaptively weighted approach in the most computationally effective way. We develop a new least-squares finite element method that works in conjunction with adaptive mesh refinement to globally balance error in approximations. This method also allows us to improve solutions in terms of both accuracy and computational cost. We use FreeFem++ to illustrate how our adaptive weighted methods affect approximated solutions to convection-dominated diffusion PDEs. We extend this method by applying it to functions with particularly tricky exact solutions, such as the Navier-Stokes equations. (Received September 19, 2009)

1056-35-256 **Fioralba Cakoni*** (cakoni@math.udel.edu), Department of Mathematical Sciences, Newark, DE 19716. *Interior Transmission Eigenvalue Problem and its Application in Inverse Scattering Theory.*

We first consider the scattering of time harmonic plane waves by a perfectly conducting infinite cylinder of cross section D. We observe that the Dirichlet eigenvalues for the Laplacian in D can be determined from the far field pattern of the scattered wave and hence from the Faber-Krahn inequality we can obtain a lower bound for the area of D. We then consider the corresponding problem for a dielectric cylinder. Here we observe that a relatively new type of spectra called transmission eigenvalues can be determined from the far field pattern of the scattered wave and show that infinitely many transmission eigenvalues exist and form a discrete set. We then obtain a Faber-Krahn type inequality for transmission eigenvalues which,if D is known, provide a lower bound on the index of refraction n(x). Of special interest is the case when cavities may be present,i.e. regions where n(x)=1.We consider both isotropic and anisotropic materials. (Received August 20, 2009)

1056-35-283 **Jesse Ratzkin*** (j.ratzkin@ucc.ie), School of Mathematical Sciences, University College Cork, Western Gateway Building, Cork, Cork 00000. *Eigenvalues and Isoperimetric Inequalities.*

I will discuss some bounds for the first eigenvalue of the Laplacian with Dirichlet boundary conditions, particularly for domains in a cone. These bounds arise from weighted isoperimetic inequalities, which are interesting themselves. Time allowing, I will also discuss some applications. (Received September 14, 2009)

1056-35-312 **Patcharin Tragoonsirisak*** (tragoonsirisakp@fvsu.edu), Dep. of Mathematics and Computer Science, Fort Valley State University, Fort Valley, GA 31030. *Blow-up phenomena due to concentrated nonlinear sources in $\mathbb{R}^N$.*

A multi-dimensional semilinear parabolic problem with a nonlinear source on the surface $\partial B$ of a $N$-dimensional ball is studied. It is shown that the problem has a unique nonnegative continuous solution $u$ before blow-up occurs. If $u$ blows up in a finite time, then under additional conditions on the initial data, it blows up everywhere on $\partial B$ only. It is proved that u always blows up in a finite time for $N \leq 2$, and blow-up can be prevented for $N \geq 3$. The effect of the source strength on the blow-up phenomena is investigated. (Received August 27, 2009)

1056-35-321 **Colleen T Ackermann*** (cackerm@vt.edu), 4900 Chipper Lane, Fairfax, VA 22032, and **William D Hardesty** (hardes1@umbc.edu), 6301 Summercrest Drive, Columbia, MD 21045. *Nucleation and Spinodal Decomposition in Ternary-component Alloys.* Preliminary report.

The Cahn-Morral System has often been used to model the dynamics of phase separation in multi-component alloys on large domains. In this paper we time independently examine phase separation on small one-dimensional domains. In particular we use AUTO to create bifurcation diagrams of equilibrium solutions for two different nonlinearities and use Matlab to observe the structure of the material at various points on the diagrams. We compare the results to determine if using different nonlinearities significantly affects the behavior of the Cahn-Morral System. This research work was completed as a part of the George Mason University Research Experiences for Undergraduates program that was supported in part by the National Science Foundation REU (DMS 0851612) and the Department of Defense ASSURE program. (Received August 28, 2009)

1056-35-381 **Beyza Aslan*** (beyza.aslan@unf.edu), University of North Florida, Department of Mathematics and Statistics, 1 UNF Dr., Bldg 14/2731, Jacksonville, FL 32224, and **William Hager**. *The Change in Electric Potential due to Lightning.*

The change in the electric potential due to lightning is evaluated using Maxwell's equations. The potential along the lightning channel is a constant which is the projection of the pre-flash potential along a piecewise harmonic eigenfunction which is constant along the lightning channel. The change in the potential outside the lightning channel is a harmonic function whose boundary conditions are expressed in terms of the pre-flash potential and the post-flash potential along the lightning channel. The expression for the lightning induced electric potential change is derived both for the continuous equations, and for a spatially discretized formulation of the continuous equations. (Received September 03, 2009)

1056-35-400 **Ronald E Mickens*** (rohrs@math.gatech.edu), Physics Department, PO Box 1744, Atlanta, GA 30314. *Front Behavior for Traveling Wave Solutions of a Modified Fisher PDE.*

We consider a Fisher type PDE in which the reaction term includes both linear and square-root functions of the dependent variable, $u(x,t)$. While our previous work demonstrates the existence of traveling wave (TW) solutions for this equation, the purpose of this presentation is to show that these solutions go to zero at a finite value of the TW variable, $z = x - ct$. This means that $U(x,t) = f(z)$ has the properties:

$$0 \leq f(z) \leq 1,$$
$$f(-\infty) = 1, \quad f(\infty) = 0$$
$$f(z) = 0, \quad z \geq z_c,$$

where $z_c$ is a constant. The method of "dominant" balance is used to calculate the behavior of $f(z)$ at the TW front, i.e., in a neighborhood of $z = z_c$. We also provide the details for the construction of a positivity preserving finite difference scheme that can be used to compute numerical solutions for the PDE. (Received September 04, 2009)

1056-35-403 **Chunguang Chen*** (cgchen@math.wvu.edu), 501 White Ave, Apt 3, Morgantown, WV 26501, and **Harumi Hattori** (hattori@math.wvu.edu), Department of Mathematics, West Virginia University, Morgantwon, WV 26506. *$L^1$ Well Posedness of Euler Equations With Dynamic Phase Boundaries.*

We discuss the well posedness of the initial value problem to Euler equations related to phase transition. The solution contains two phase boundaries moving in opposite directions. Entropy condition and kinetic relationship are used as the main admissibility criteria to select the physically relevant solution. We show the existence of the entropy solution under a suitable Finiteness Condition and a Stability Condition guarantees the stability of the problem in $L^1 \bigcap BV$ and the existence of a Lipschitz semigroup of solutions. We also discuss the well posedness of the problem given that the wave speeds do not differ significantly between different phases. (Received September 04, 2009)

1056-35-436 **Abbas Momeni*** (momeni@mast.queensu.ca), Department of Mathematics and Statistics, Queen's University, Jeffery Hall, University Ave., Kingston, Ontario k7L3N6, Canada. *A variational principle associated with a certain class of boundary value problems.*

A variational principle is introduced to provide a new formulation and resolution for several boundary value problems. Indeed, we consider systems of the form

$$\begin{cases} \Lambda u = \nabla\Phi(u), \\ \beta_2 u = \nabla\Psi(\beta_1 u) \end{cases}$$

where $\Phi$ and $\Psi$ are two convex functions and $\Lambda$ is a possibly unbounded self-adjoint operator modulo the boundary operator $\mathcal{B} = (\beta_1, \beta_2)$. We shall show that solutions of the above system coincide with critical points of the functional

$$I(u) = \Phi^*(\Lambda u) - \Phi(u) + \Psi^*(\beta_2 u) - \Psi(\beta_1 u)$$

where $\Phi^*$ and $\Psi^*$ are Fenchel-Legendre dual of $\Phi$ and $\Psi$ respectively. Note that the standard Euler-Lagrange functional corresponding to the system above is of the form,

$$F(u) = \frac{1}{2}\langle \Lambda u, u\rangle - \Phi(u) - \Psi(\beta_1 u).$$

An immediate advantage of using the functional $I$ instead of $F$, is to obtain more regular solutions and also the flexibility to handle boundary value problems with nonlinear boundary conditions. Applications to Hamiltonian systems and semi-linear Elliptic equations with various linear and nonlinear boundary conditions are also provided. (Received September 07, 2009)

1056-35-490 **Maomao Cai*** (chloecai@weber.edu), 1702 University Circle, Ogden, UT 84408-1702, and **Dening Li** and **Chontita Rattanakul**. *Solutions for 2-Dimensional Coupled Kuramoto-Sivashinsky-KdV Equations.*

A stabilized Kuramoto-Sivanshinsky system consists of a mixed Kuramoto-Sivanshinsky-Korteweg-de Vires equation, linearly coupled to an extra linear dissipative equation. This system is proposed to describe the surface waves on multi-layered liquid films. In this work, we study a stabilized Kuramoto-Sivanshinsky system in two-dimensional space. Our studies consist of three parts: first, to investigate the stability of the solution to this system, we establish a priori energy estimate for the linearized problem of this non-linear system; second, we use linear iteration to prove the local existence of the solution to this system; third, we use a weak global priori energy estimate to further prove the global existence and uniqueness of classical solutions to this system. (Received September 09, 2009)

1056-35-532 **Roberto Triggiani*** (rt7u@virginia.edu), Department of Mathematics, P. O. Box 400137, University of Virginia, Charlottesville, VA 22904. *Uniform stabilization of the system of dynamic elasticity by non-linear boundary dissipation.*

We showed that the system of dynamic elasticity is uniformly stable in its right state space by means of a non-linear, non-local dissipation acting on (a portion of) the boundary. A micro-local argument provides a key a-priori boundary estimate for a corresponding linear problem ($B * L$ continuous in $L_2$ in time and space). (Received September 11, 2009)

1056-35-550 **Jin Cheng*** (jcheng@fudan.edu.cn), School of Mathematical Sciences, Fudan University, Shanghai, Shanghai 200433, Peoples Rep of China, **Shuai Lu** (shuai.lu@oeaw.ac.at), Johann Radon Institute for Computational, and Applied Mathematics, A-4040 Linz, Austria, and **Masahiro Yamamoto** (myama@ms.u-tokyo.ac.jp), Gardaute School of Mathematical Sciences, the University of Tokyo, Tokyo, 153-8914, Japan. *Reconstruction of the Stefan-Boltzmann coefficients on the heat transfer process.*

In this talk, we present our results about an inverse problem on the determination of boundary coefficients within the framework of Stefan-Boltzmann radiation conditions for the heat transfer process in a solid material. The problem is motivated by the corrosion detection in the production of zinc-coated steel sheets. The mathematical formulation for the forward and inverse problem is introduced in the context and uniqueness of the inverse problem is proved. The finite difference method is utilized for the discretization of the forward problems. Based on our analysis, we propose a reconstruction method for solving the inverse problem. Some regularization techniques are implemented to overcome the ill-posedness of the problem. Numerical simulation shows that the reconstruction method is stable and effective. (Received September 12, 2009)

1056-35-560 **Stephen Pankavich*** (sdp@uta.edu), 411 S Nedderman Dr, Box 19408, Arlington, TX 76019. *Analysis and Simulation of a One-dimensional Plasma Model.*

The fundamental kinetic description of a collisionless plasma is given by the Vlasov-Maxwell (VM) equations. When relativistic velocity effects are not present in the model, the existence and regularity of classical solutions to this system of nonlinear hyperbolic PDE is still unknown, even for the lowest dimensional representation. We consider a one-dimensional model problem which displays the identical difficulties as (VM) and present analytical and numerical results concerning the regularity and behavior of solutions. (Received September 12, 2009)

1056-35-569 **George Avalos*** (gavalos@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588. *Concerning the Qualitative of a Coupled Fluid-Structure Semigroup.*

In this talk we shall derive certain qualitative properties for a partial differential equation (PDE) system which comprises (parabolic) Stokes fluid flow and a (hyperbolic) elastic structure 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. (Received September 13, 2009)

1056-35-640 **Matthias Eller***, Department of Mathematics, Georgetown University, 37th & O Street NW, Washington, DC 20016. *Boundary regularity for Maxwell's equation with applications to shape optimization.*

We consider weak solutions to a boundary value problem for Maxwell's equations with a dissipative boundary condition. Energy estimates show that the tangential components of the electric and the magnetic field are in $L_2$. However, since the boundary is characteristic, no statement can be made about the normal components of the vector fields. We manage to obtain $L_2$ regularity for these normal components by including a divergence condition on the initial data. This result does not follow from the trace theorem in Sobolev Spaces, hence it can be classified as a "hidden regularity" result. Boundary regularity of weak solutions is of importance when it come to shape optimization. The shape derivative for this boundary value problem is established. This is a joint work with John Cagnol from the Pôle Universitaire Lèonard da Vinci in Paris. (Received September 15, 2009)

1056-35-661 **Andras Domokos***, Department of Mathematics and Statistics, California State University at Sacramento, Sacramento, CA 95819. *Subelliptic regularity in non-nilpotent cases.*

In this talk we will present results regarding the regularity of weak solutions for subelliptic quasilinear PDE's of the form

$$\sum_{i=1}^{n} X_i^* \left(a_i(x, \mathfrak{X}u)\right) = 0\,,\ \text{in}\ \Omega \subset \mathbb{R}^N\,, \tag{1}$$

where $n \leq N$ and $\mathfrak{X} = \{X_1, ..., X_n\}$ is a Hörmander system of vector fields. We will focus on nonlinear and non-nilpotent cases which were the least studied. (Received September 15, 2009)

1056-35-663 **David Maxwell*** (damaxwell@alaska.edu), Department of Mathematics and Statistics, PO Box 756660, Fairbanks, AK 99775. *A Model Problem for Conformal Parameterizations of the Einstein Constraint Equations.*

We investigate the possibility that the conformal and conformal thin sandwich (CTS) methods can be used to parameterize the set of solutions of the vacuum Einstein constraint equations. To this end we develop a model problem obtained by taking the quotient of certain symmetric data on conformally flat tori. Specializing the model problem to a three-parameter family of conformal data we observe a number of new phenomena for the conformal and CTS methods. Within this family, we obtain a general existence theorem so long as the mean curvature does not change sign. When the mean curvature changes sign we find that for certain data solutions exist if and only if the transverse-traceless tensor is sufficiently small, and that when solutions exist there are generically more than one. Moreover, the theory for mean curvatures with changing sign is shown to be extremely sensitive with respect to the value of a coupling constant in the Einstein constraint equations. (Received September 15, 2009)

1056-35-667 **Azmy S Ackleh**, Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010, **Keng Deng*** (deng@louisiana.edu), Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010, and **Qihua Huang**, Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010. *A Finite Difference Approximation for an Amphibian Juvenile-adult Migration System.*

we consider an amphibian juvenile-adult population migrating between multi-ponds. We assume that juveniles are structured by age and adults are structured by size. This leads to a system of first order nonlocal hyperbolic equations. A finite difference approximation to this system is developed. Existence-uniqueness of the weak solution to the system is established and convergence of the finite difference approximation to the unique solution is proved. (Received September 15, 2009)

1056-35-681 **Samuel Walsh*** (Samuel_Walsh@brown.edu). *Stratified steady water waves.*

We will discuss two-dimensional, periodic, stratified, traveling water waves propagating over an impermeable flat bed and with a free surface. The wave's motion is assumed to be driven by surface tension on the upper boundary and a gravitational force acting on the body of the fluid. Such waves are commonly seen to form when, for example, a wind blows over a quiescent body of water. We shall present some new results on the existence of global continua of classical solutions of this type. In the process, we shall also answer some open questions for the constant density case. (Received September 15, 2009)

1056-35-685 **Vladimir A. Volpert** and **Esteban Urdiales*** (eu@u.northwestern.edu). *Stability of spherically propagating thermal frontal polymerization waves.* Preliminary report.

Frontal polymerization (FP) is the process in which monomers are converted into polymers by means of a spatially localized reaction zone. Thermal frontal polymerization (TFP) waves propagate due to heat released in chemical reactions. Spherically propagating TFP waves were first observed in experiments. After a brief period of ignition by an external UV source, the front begins to expand radially. Once the front attains a critical size, it becomes unstable, resulting in so called 'spin modes'. These 'spin modes' are manifested as slightly raised regions that travel on the surface of the expanding spherical front. A basic solution is constructed which describes a spherically symmetric outward propagating front of radius $R(\tau)$. A stability analysis of the basic solution is then conducted. (Received September 15, 2009)

1056-35-686 **Jun Yu*** (junyu@zscas.edu.cn), Shaoxing, 312000, Peoples Rep of China. *Symmetries and algebras for a MKdV-type equation in (2+1)-dimension.* Preliminary report.

In this paper, a (2+1)-dimensional MKdV-type equation proposed by Hietarinta is changed to a more universal form with a variable coefficient. Using the formal series symmetry method, a set of infinitely many symmetries with a arbitrary function for this system is obtained, and then the corresponding Lie algebra structure is also given. (Received September 15, 2009)

1056-35-725 **Aaron S. Donahue** (adonahue@rohan.sdsu.edu), Department of Mathematics and Statistics, San Diego State University, 5500 Campanille Dr., San Diego, CA 92182, and **Samuel S.P. Shen*** (shen@math.sdsu.edu), Department of Mathematics and Statistics, San Diego State University, 5500 Campanille Dr., San Diego, CA 92182. *A Detailed Bifurcation Diagram and Semi-Analytic Solutions of the Forced Korteweg-de Vries Equation.*

The surface wave in a 2-dimensional water channel caused by a bump moving at uniform speed along the bottom of the channel can be modeled by the forced Korteweg-de Vries (fKdV) equation. Due to the forcing term, the fKdV equation has a variety of solutions different from the free KdV equation. For example, the fKdV can generate a train of solitons of equal size, and the fKdV allows an experiment of a train of two equal size solitons colliding with another train of two equal size solitons. To date, the fKdV equation has not been found integrable. However, the non-stationary transicritical fKdV solutions have beautiful and orderly geometrical properties, which allow semi-analytic solutions to be found. This talk will present the following results: (i) a new approximation formula for the upstream solitons based on a semi-analytic approach, verified by the numerical solutions and a statistical regression, (ii) a detailed bifurcation diagram of the fKdV solutions ranging from sub-critical cnoidal waves, hydraulic fall, transcritical waves, to the super-critical solitary waves, and (iii) various kinds of numerical solutions, their corresponding geometric interpretation of the semi-analytic solutions, and stability simulation results. (Received September 16, 2009)

1056-35-744 **Katharine A. Ott*** (katharine.ott@uky.edu), Department of Mathematics, 715 Patterson Office Tower, University of Kentucky, Lexington, KY 40506, and **Russell Brown**. *The mixed boundary value problem in Lipschitz domains.*

In this talk I will discuss recent progress on the mixed problem for the Laplacian in Lipschitz domains. In this setting we prove existence and uniqueness of solutions to the mixed problem when the Neumann boundary data lies in $L^p$ and the Dirichlet data lies in $W^{1,p}$ for $p$ near 1. This is joint work with R. Brown. (Received September 16, 2009)

1056-35-748 **Steve Zelditch*** (zelditch@math.northwestern.edu), Department of Mathematics, Northwestern University, Evanston, IL 60208. *Quantum ergodic restriction theorems.*

Quantum ergodicity is a property of almost the full sequence of eigenfunctions of a Riemannian manifold with ergodic geodesic flow: the eigenfunctions becomes uniformly distributed in phase space. By a quantum ergodic resctriction theorem we mean the question whether the restrictions of eigenfunctions to a hypersurface are quantum ergodic along the hypersurface. Simple examples show that this is sometimes not the case. In my talk, sufficient conditions will be given for restrictions of eigenfunctions to be quantum ergodic. Based on joint work with John Toth and work in progress with John Toth, Hamid Hezari and Hans Christianson (Received September 16, 2009)

1056-35-765 **Zhijun Qiao*** (qiao@utpa.edu), Edinburg, TX 78541, and **Jaime Lopez** and **Guillermo Garza**. *PDE Analysis and Cross-Range Imaging of Synthetic Aperture Radar.* Preliminary report.

We present a deeper observation and clarification of the mathematics of cross range imaging of SAR data. We begin with an introduction to the cross-range SAR image scenario, and establish the relationship between the signal received by the radar antenna and the desired target function. We then evaluate the matched-filtered version of the target function by use of Fourier transforms. Sampling of the echoed signal is also discussed to introduce the concept of the radar system Pulse Repetition Frequency (PRF), and its affect on the digitized signal. A method of reducing the PRF via slow-time compression is also explained. Importantly, we present a detailed derivation of slow-time sample spacing, which corrects the previous formulation. A cross-range imaging algorithm and a comparison of the results are given based on our slow-time sample spacing. Finally, we discuss a mathematical model for SAR imaging – Maxwell's equations for SAR image reconstruction. (Received September 17, 2009)

1056-35-798 **Andras Vasy***, Department of Mathematics, Building 380, Stanford University, 450 Serra Mall, Stanford, CA 94305-2125. *Diffraction at corners for the wave equation on differential forms.*

In this talk I will describe the propagation of singularities for the wave equation on differential forms with natural (i.e. relative or absolute) boundary conditions on Lorentzian manifolds with corners, which in particular includes a formulation of Maxwell's equations. These results are analogous to those obtained by the speaker for the scalar wave equation, and for the wave equation for systems with Dirichlet or Neumann boundary conditions. The main novelty is thus the presence of natural boundary conditions, which effectively make the problem non-scalar, even 'to leading order', at corners of codimension at least two.

The main tool used is microlocal energy estimates via positive commutators, using Melrose's totally characteristic (or b-) pseudodifferential operators as microlocalizers. (Received September 17, 2009)

1056-35-807 **Sergei Fomin*** (sfomin@csuchico.edu), Khalifa University of Science, Technology and, Research (KUSTAR), P.O. Box 127788, Abu Dhabi, United Arab Emirates, and **Vladimir Chugunov** (chug@ksu.ru), Center of Information Technologies, Kazan State University, Kremlevskaya 18, Kazan, 420008, Russia. *Fractional differential equations for modeling anomalous diffusion in porous medium.*

Analysis of diffusion in a complex environment shows that the conventional diffusion equation based on Fick's law fails to model the anomalous character of the diffusive mass transport observed in the field and laboratory experiments. Two regimes of anomalous diffusion are identified. One regime, which is called sub-diffusion, is characterized by the slower propagation of the concentration front, so that the squared distance of the front passage requires longer time than in the case of the classical Fickian diffusion. The second regime (called super-diffusion) is characterized by the higher diffusion rate. Both regimes can be modeled by non-local diffusion equation with temporal and spatial fractional derivatives. In the present paper the examples of the equations that can be used for describing the anomalous mass transport are presented and some important properties of these equations are discussed. Analytical solutions of some particular problems of sub-diffusion and super-diffusion in the fractal media of various geometries are obtained by the method of Laplace transformations. Using the Mathematica 7 computer algebra system, the obtained solutions are illustrated graphically. (Received September 17, 2009)

1056-35-837 **Robert R Jensen*** (rjensen@luc.edu), Dept. Math. and Statistics, Loyola University Chicago, 6525 N. Sheridan Rd., Chicago, IL 60626. *$\Delta_\infty$ is well defined - a new proof.*

In a recent paper Yifeng Yu proved that if $\Delta_\infty U = g$ and $\Delta_\infty U = h$ where $g$ and $h$ are continuous functions, then $g = h$. The proof is clever and lengthy. I will present a significantly shorter proof of the same result, but depending heavily on some of the special properties of the solutions of the $\Delta_\infty$. (Received September 17, 2009)

1056-35-842 **Chang-Yeol Jung*** (changyeoljung@gmail.com), Ulsan, South Korea, and **Roger Temam** and **Makram Hamouda**. *Asymptotic analysis for the 3D primitive equations in a channel.*

In this article, we give an asymptotic expansion, with respect to the viscosity which is considered here to be small, of the solution of the 3D linearized Primitive Equations (EPs) in a channel with lateral periodicity. A rigorous convergence result, in some physically relevant space, is proven. This allows, among other consequences, to confirm the natural choice of the non-local boundary conditions for the non-viscous PEs. (Received September 17, 2009)

1056-35-878 **Dumitru Motreanu*** (motreanu@univ-perp.fr), University of Perpignan, Department of Mathematics, 66860 Perpignan, France. *Multiple and sign-changing solutions for nonlinear elliptic problems with p-Laplacian.*

The existence of multiple solutions is shown for a nonlinear elliptic problem involving the p-Laplacian operator together with (p-1)-sublinear and (p-1)-superlinear terms. Precise sign information is provided for all the solutions. The existence of at least one sign-changing solution is guaranteed under the imposed hypotheses. The approach relies on variational methods and Morse theory. (Received September 18, 2009)

1056-35-902 **Stephen McDowall*** (stephen.mcdowall@wwu.edu), Department of Mathematics, 516 High Street, MS 9063, Bellingham, WA 98225-9063. *Inverse transport theory and optical tomography for media with varying index of refraction.*

Optical tomography is the use of near-infrared light to determine the optical absorption and scattering properties of a medium. In the stationary Euclidean setting the dynamics are modeled by the radiative transport equation, which assumes that in the absence of interaction particles follow straight lines. Here we consider the problem in the presence of a (simple) Riemannian metric where particles follow the geodesic flow of the metric. This non-Euclidean geometry models a medium which has a continuously varying refractive index. We will present uniqueness results for two types of measurements: (1) angularly-dependent measurements and (2) the case where the information available at the boundary is averaged over angle. We show that knowledge of the albedo operator, that which maps incoming flux to outgoing flux at the boundary, uniquely determines the absorption and scattering properties of the medium. We also characterize the non-uniqueness present in the problem when the absorption is allowed to depend on direction as well as position. (Received September 18, 2009)

1056-35-913 **Florentina Tone*** (ftone@uwf.edu), Department of Mathematics and Statistics, University of West Florida, 11000 University Parkway, Pensacola, FL 32514. *On the Long-Time H2-Stability of the Implicit Euler Scheme for the 2D Magnetohydrodynamics Equations.*

In this talk we consider the two-dimensional magnetohydrodynamics equations, we discretize these equations in time using the implicit Euler scheme and with the aid of the classical and uniform discrete Gronwall lemma, we prove that the scheme is H2-uniformly stable in time. (Received September 18, 2009)

1056-35-920 **Cristian E Gutierrez** (gutierre@temple.edu), 1805 N. Broad St., Temple university, Dept of Mathematics, Philadelphia, PA 19122, and **Henok Z Mawi*** (mawi@templeedu), 1805 N. Broad St., Temple University, Dept of Mathematics, Philadelphia, PA 19122. *The refractor problem with loss of energy and Monge - Ampère type of Equation.*

Given $\Omega, \Omega^* \subset S^{n-1}$; two positive functions $f \in L^1(\Omega), g \in L^1(\Omega^*)$; and two homogeneous media I and II with indices of refraction $n_1$ and $n_2$ respectively, suppose from a light source at the origin $O$ inside medium I, a light ray emanates with intensity $f(x), x \in \Omega$ and hits an interface $\mathcal{R}$ between media I and media II. Then the ray of light bends in a direction $m$ according to Snell's law, and it also loses its intensity by a factor according to Fresnel's formulas. Set $x = \mathcal{T}_{\mathcal{R}}(m)$. Finding the weak solution of the general refractor problem for a light beam with illumination intensity $f$ and prescribed illumination intensity $g$ involves finding a radial graph

$$\mathcal{R} = \{x\rho(x) | x \in \Omega\}$$

such that for every Borel set $\omega \subset \Omega^*$

$$\int_{\mathcal{T}_{\mathcal{R}}(\omega)} f(x) t_{\mathcal{R}}(x) dx = \int_{\omega} g(m) dm$$

where $t_{\mathcal{R}}(x)$ is the fraction of intensity lost as given by Fresnel's formulas. In this work we will use ellipsoidal approximation to solve the problem. Moreover we notice that the solution satisfies a fully nonlinear partial differential equation of Monge - Ampère type. This is joint work with Prof. C. E. Gutierrez. (Received September 18, 2009)

1056-35-960 **Irena Lasiecka***, University of Virginia, Department of Mathematics, P. O. Box 400137, Charlottesville, VA 22904. *Well-posedness of weak and strong solutions in nonlinear flow of gas and structure interactions.*

Dynamics for a class of nonlinear hyperbolic systems modeling gas -flow interactions will be considered. These are Euler equations (flow of gas) coupled at the interface with nonlinear plate (structure) equations. The coupling leads to non-conservative and non-dissipative models with supercritical sources.

It is shown that finite energy solutions do exist globally , are unique and satisfy Hadamard wellposedness criterium. In addition, long time behavior will be discussed. The proof is based on compensated compactness, harmonic analysis tools along with stability methods introduced in [I. Chueshov and I. Lasiecka, *Long-time behavior of second order evolution equations with nonlinear damping*, Memoirs of AMS, vol.195, no. 912, AMS, 2008.] (Received September 18, 2009)

1056-35-978 **Shusen Ding*** (sding@seattleu.edu), Department of Mathematics, Seattle University, Seattle, WA 98122. *Norm Estimates for Composite Operators Applied to Harmonic Forms.* Preliminary report.

In this presentation, we will discuss the singular integrals of composite operators, such as the homotopy operator $T$ and Green's operator, applied to the harmonic forms in a domain $\Omega \subset \mathbf{R}^n$. We all know that the harmonic forms are differential forms satisfying some version of the harmonic equation. In this talk, we study the differential forms satisfying the nonlinear partial differential equation $d^\star A(x, du) = B(x, du)$ which is called the non-homogeneous A-harmonic equation, where $A : \Omega \times \wedge^l(\mathbf{R}^n) \to \wedge^l(\mathbf{R}^n)$ and $B : \Omega \times \wedge^l(\mathbf{R}^n) \to \wedge^{l-1}(\mathbf{R}^n)$ satisfy the conditions: $|A(x, \xi)| \le a|\xi|^{p-1}$, $A(x, \xi) \cdot \xi \ge |\xi|^p$ and $|B(x, \xi)| \le b|\xi|^{p-1}$ for almost every $x \in \Omega$ and all $l$-forms $\xi$. Here $\wedge^l(\mathbf{R}^n)$ is the set of all differential $l$-forms defined in $\mathbf{R}^n$, $a, b > 0$ are constants and $1 < p < \infty$ is a fixed exponent associated with the non-homogeneous A-harmonic equation. (Received September 19, 2009)

1056-35-984 **Gisèle MOPHOU*** (gmophou@univ-ag.fr), Université des Antilles et de la Guyane, Département de Maths-Info, Campus de Fouillole, 97122 Pointe-à-Pitre, Guadeloupe. *Existence and uniqueness of mild solutions to impulsive fractional differential equations.*

This paper is concerned with the existence and uniqueness of mild solution to an impulsive fractional semilinear differential equations. The results are obtained by means of fixed point methods. We also give an example of such problems. (Received September 19, 2009)

1056-35-1009 **Hamid Hezari*** (hezari@math.mit.edu), 77 Mass Ave, MIT/Department of Mathematics, Room 2-306, Cambridge, MA 02139, and **Steve Zelditch**. *Inverse Spectral Problems for Analytic Domains in $\mathbb{R}^n$.*

This is a report of a recent joint work with Steve Zeldtich on inverse spectral problems for analytis domains in $\mathbb{R}^n$. We show that bounded analytic domains in $\mathbb{R}^n$ with mirror symmetries across all coordinate axes are spectrally determined among other such domains. Our approach builds on finding concrete formulas for the wave invariants at a bouncing ball orbit. The wave invariants are calculated from a stationary phase expansion applied to a well-constructed microlocal parametrix for the trace of the resolvent. (Received September 19, 2009)

1056-35-1012 **Hamid Hezari*** (hezari@math.mit.edu), 77 Mass Ave, MIT/Department of Mathematics, Room 2-306, Cambridge, MA 02139, and **Steve Zelditch**. *Spectral rigidity of analytic plane domains with one mirror symmetry.*

This is a report of a recent joint work with Steve Zleditch on isospectral deformations of plane domains.

It is known that there exist non-isometric isospectral plane domains, but all of the known examples have corners and in particular are not smooth. The original problem of Kac, "Can one hear the shape of a drum?" is therefore open if one interprets "drum" to mean a smooth drum. The only domain known to be determined by its spectrum among all plane domains is the standard disc. It is not known if ellipses are spectrally determined, even among smooth plane domains. The purpose of this short talk is to prove that bounded real analytic plane domains with one symmetry are spectrally rigid among all real analytic domains, including those without any symmetries. The proofs are based on the calculation and study of variational derivatives of the "wave trace invariants" associated to a bouncing ball orbit. (Received September 19, 2009)

1056-35-1024 **Peter Kuchment*** (kuchment@math.tamu.edu), Mathematics Department, Texas A&M University, College Station, TX 77843-3368, **Leonid Kunyansky** (leonk@math.arizona.edu), Mathematics Department, University of Arizona, Tucson, AZ, **Moritz Allmaras** (allmaras@math.tamu.edu), Mathematics Department, Texas A&M University, College Station, TX 77843-3368, and **Wolfgang Bangerth** (bangerth@math.tamu.edu), Mathematics Department, Texas A&M University, College Station, TX 77843-3368. *Ultrasound modulated electrical impedance and optical tomography.* Preliminary report.

Recent years have witnessed emergence of the so called hybrid modalities of medical imaging, where two different types of physical signals (e.g., ultrasound and electromagnetic waves) are used simultaneously and modulate each other in order to get a good resolution image. The mathematics of two types of such imaging methods will be discussed. (Received September 20, 2009)

1056-35-1029 **Peter Kuchment*** (kuchment@math.tamu.edu), Mathematics Department, Texas A&M University, College Station, TX 77843-3368, **David Darrow** (dpdarrow@utmb.edu), UT Medical Branch at Galveston, Galveston, TX, **Yulia Hristova** (ygh@math.tamu.edu), Mathematics Department, Texas A&M University, College Station, TX 77843-3368, and **Guido Kanschat** (kanschat@math.tamu.edu), Mathematics Department, Texas A&M University, College Station, TX 77843-3368. *On detection of small low emission sources.*

The problem of detecting the presence of a low emission small object on a high random background will be discussed. (Received September 20, 2009)

1056-35-1031 **Changyou Wang*** (cywang@ms.uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40506. *Homogenization in $L^\infty$.* Preliminary report.

In this talk, we will discuss the $\Gamma$-limit of the $L^\infty$-functionals as $\epsilon$ tends to zero:

$$esssup_{x\in[0,1]^n} H(\frac{x}{\epsilon}, \frac{u}{\epsilon}, \nabla u),$$

where $H$ is 1-period in the first two variables. The goal is to try identifying the effective Hamiltonian function. Also we will discuss the convergence of viscosity solutions of the corresponding Aronsson's equations. (Received September 20, 2009)

1056-35-1071 **Dean R. Baskin*** (dbaskin@math.stanford.edu), Stanford University, Department of Mathematics, Building 380, Stanford, CA 94305. *Strichartz estimates on asymptotically de Sitter spaces.*

Asymptotically de Sitter spaces are Lorentzian manifolds that resemble the de Sitter space near infinity. They are asymptotic solutions of the Einstein equations with positive cosmological constant. We discuss Strichartz estimates for solutions of the Klein-Gordon and wave equations on these spaces. (Received September 20, 2009)

1056-35-1074 **Petronela Radu*** (pradu@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588, and **Grozdena Todorova** and **Borislav Yordanov**. *Bridging the asymptotic behavior of solutions to hyperbolic equations with parabolic equations.*

The Cattaneo-Vernotte equation offers physical insight into the connection between the heat equation and the wave equation with linear damping. We show how one may use this insight to establish sharp energy decay rates for solutions to wave equations with linear damping and variable coefficients. The difficulty of dealing with operators with variable coefficients is eliminated by proving an abstract version of the diffusion phenomenon which allows one to transfer information from the parabolic to the hyperbolic problem as the time goes to infinity. The asymptotic estimates for the parabolic problem with variable coefficients are obtained by proving a weighted Nash-type inequality. (Received September 20, 2009)

1056-35-1089 **George Avalos** and **Daniel Toundykov*** (dtoundykov@math.unl.edu), University of Nebraska-Lincoln, Department of Mathematics, P.O. Box 880130, Lincoln, NE 68588. *Boundary stabilization of nonlinear structural acoustic interactions with interface on a Reissner-Mindlin plate.*

We address observability and energy decay for a structural-acoustics model comprised of a wave equation coupled with a Reissner-Mindlin plate. Both components of the dynamics are subject to localized boundary damping: the acoustic dissipative feedback is restricted to the flexible boundary and only *a portion* of the rigid wall; the plate is likewise damped on a segment of its boundary.

The derivation of the "coupled" stabilization/observability inequalities requires weighted energy multipliers related to the geometry of the domain, and special tangential trace estimates for the displacement and the filament angles of the Reissner-Mindlin plate model. The behavior of the energy at infinity can be quantified by a solution to an explicitly constructed nonlinear ODE. The nonlinearities in the feedbacks may include sub- and super-linear growth at infinity, in which case the decay scheme presents a trade-off between the regularity of solutions and attainable uniform dissipation rates of the finite-energy. (Received September 22, 2009)

1056-35-1100 **Netra P. Khanal*** (netra.khanal@uwc.edu), 614 Oakfield St., apt 3, West Bend, WI 53090, **Jiahong Wu** (jiahong@math.okstate.edu), 401 Math Sciences, Department of Mathematics, Oklahoma State University, Stillwater, OK 74078, and **Juan-Ming Yuan** (jmyuan@pu.edu.tw). *The Kawahara equation in weighted Sobolev spaces.*

The initial- and boundary-value problem for the Kawahara equation, a fifth-order KdV type equation, is studied in weighted Sobolev spaces. This functional framework is based on the dual-Petrov–Galerkin algorithm, a numerical method proposed by Shen (2003 SIAM J. Numer. Anal. 41 1595–619) to solve third and higher odd-order partial differential equations. The theory presented here includes the existence and uniqueness of a local mild solution and of a global strong solution in these weighted spaces. If the L2-norm of the initial data is sufficiently small, these solutions decay exponentially in time. Numerical computations are performed to complement the theory. (Received September 20, 2009)

1056-35-1108 **Marian Bocea*** (marian.bocea@ndsu.edu), North Dakota State University, Department of Mathematics, NDSU Dept. # 2750, P.O. Box 6050, Fargo, ND 58108-6050. *$\Gamma$-convergence of power-law functionals with variable exponents.*

Motivated in part by models of (first-failure) dielectric breakdown, we obtain several $\Gamma$-convergence results for power-law functionals with variable exponents. Some connections with the generalization of the $\infty$-Laplace equation to the variable exponent setting will be presented. This is joint work with Mihai Mihăilescu (University of Craiova, Romania, and Central European University, Budapest, Hungary) (Received September 20, 2009)

1056-35-1136 **Miyoun Jung** (gomtaeng@math.ucla.edu), 405 Hilgard Avenue, Los Angeles, CA, **Xavier Bresson** (xbresson@math.ucla.edu), 405 Hilgard Avenue, Los Angeles, CA, **Tony F Chan** (chan@math.ucla.edu), 405 Hilgard Avenue, Los Angeles, CA , and **Luminita A Vese*** (lvese@math.ucla.edu), 405 Hilgard Avenue, Los Angeles, CA. *Color Image Restoration Using Nonlocal Mumford-Shah Regularizers.*

We introduce image restoration algorithms based on the Mumford-Shah model and nonlocal image information. The standard Ambrosio-Tortorelli and Shah models use local neighborhood information, which is sufficient to denoise smooth regions with sharp boundaries. However, textures are not local in nature and require semi-local/non-local information to be denoised efficiently. Inspired from recent work (Buades, Coll, Morel, Gilboa, Osher), we extend the standard models of Ambrosio-Tortorelli and Shah approximations to Mumford-Shah functionals to work with nonlocal information, for better restoration of fine structures and textures. We present several applications of the proposed nonlocal MS regularizers in image processing such as color image denoising, color image deblurring in the presence of Gaussian or impulse noise, color image inpainting, and color image super-resolution. In all the applications, the proposed nonlocal regularizers produce superior results over the local ones, especially in image inpainting with large missing regions. Experimental results and comparisons between the proposed nonlocal methods and the local ones are shown. (Received September 21, 2009)

1056-35-1186 **James O'Beirne*** (jobeirn1@gmu.edu). *Modeling Phase Separation in Ternary Alloys.*

We examine a type of phase separation called nucleation which occurs after an alloy is quenched. Nucleation is characterized by the formation of discrete droplets of an individual material speckled throughout the otherwise homogeneous domain; this process weakens the composition and diminishes the value of the material. We simulate this phenomenon using the Cahn-Morral model by employing numerical continuation via AUTO. (Received September 21, 2009)

1056-35-1191 **Lokenath Debnath*** (debnathl@utpa.edu), Department of Mathematics, University of Texas-Pan American, 1201 W. University Dr., Edinburg, TX 78539. *The Generation and Propagation of Water Waves on a Running Stream.*

This paper deals with the generation and propagation of water waves on a running stream. Both linear and nonlinear problems will be presented. Some resonant phenomena will be discussed. (Received September 21, 2009)

1056-35-1213 **Dambaru Bhatta*** (bhattad@utpa.edu), 1201 West University Drive, Department of Mathematics, Edinburg, TX 78539, **Mallikarjunaiah S. Muddamallappa**, Department of Mathematics, Texas A&M University, Mail Stop 3368, College Station, TX 77843, and **Daniel N. Riahi**, 1201 West University Drive, Department of Mathematics, Edinburg, TX 78539. *On Nonlinear Evolution of Convective Flow in an Active Mushy Layer.*

Here we consider the convective flow in a horizontal mushy layer during alloy solidification and based on particular set of parameters that have been used to conduct experiments. The mushy layer, which has a permeable mush-liquid interface, is treated as an active porous media with variable permeability. Using numerical and analytical methods, the solutions to the evolution equation of Landau type are calculated for both super-critical and sub-critical conditions. The results for marginal stability curve, linear and first-order solutions for the vertical velocity component and the solid volume fraction within the mushy layer as functions of space and time variables. (Received September 21, 2009)

1056-35-1218 **Alexei Rybkin*** (arybkin@alaska.edu), Depart of Math and Statistics, University of Alaska Fairbanks, Fairbanks, AK 99775. *On meromorphic solutions to the Korteweg-de Vries equation with non-decaying initial data supported on a left half line.*

We show that under the KdV flow an initial profile supported on a left semi-axis from a very broad function class (without any decay assumption) instantaneously evolves into a meromorphic function with no poles on the real line. Our treatment is based on a suitable modification of the inverse scattering transform and a detailed investigation of the Titchmarsh-Weyl m-function. As by-product, we improve some related results by others. (Received September 21, 2009)

1056-35-1228 **Jose Miguel Urbano*** (jmurb@mat.uc.pt), Departamento de Matematica, Universidade de Coimbra, 3001-454 Coimbra, Portugal. *Limits as $p(x) \to \infty$ of $p(x)$-harmonic functions.*

We study the limit as $p(x) \to \infty$ of solutions to $-\Delta_{p(x)} u = 0$ in a domain $\Omega$, with Dirichlet boundary conditions. Our approach consists in considering sequences of variable exponents converging uniformly to $+\infty$ and analyzing how the corresponding solutions of the problem converge and what equation is satisfied by the limit.

This is a joint work with Juan J. Manfredi (Pittsburgh, USA) and Julio D. Rossi (Buenos Aires, Argentina). (Received September 21, 2009)

1056-35-1233 **Ray Treinen*** (treinen@math.ksu.edu), 138 Cardwell Hall, Kansas State University, Manhattan,, KS 66502. *On the symmetry and existence of solutions of some floating drop problems.*

Floating drops are configurations of three fluids in equilibrium. Presumably one fluid has significantly less volume, and is the drop. Floating drops may arise in bounded containers, or in unbounded regions, and the drop may be either more or less dense than the supporting fluid. These cases are called heavy or light drops. Presented here is a general existence theorem for symmetric configurations. A theorem is presented on the symmetry of the configurations which form a partition of $\mathbb{R}^3$. (Received September 21, 2009)

1056-35-1238 **Gang Bao*** (bao@math.msu.edu), Department of Mathematics, Wells Hall, Michigan State University, East Lansing, MI 48824, and **Junshan Lin** and **Faouzi Triki**. *Inverse Source Problems for Electromagnetics.* Preliminary report.

This work is concerned with the well-posedness study and numerical solution of the inverse source problem. By using multiple frequency boundary measurements of the field, our recent results on uniqueness and stability of the inverse problem will be presented. A numerical method based on the continuation approach will be discussed along with examples. The on-going and future research on this and related topics will be highlighted. (Received September 21, 2009)

1056-35-1260 **Franz William Hamilton*** (fhamilto@gmu.edu), 10285 Winged Elm Circle, Manassas, VA 20110. *Parameter Estimation in a System of Differential Equations.*

Given a set of data points and a prescribed system of differential equations used for modeling an event, the objective is predicting future values utilizing these differential equations. However, these differential equations often have unknown parameters. The challenge becomes figuring out the value the parameter(s) should be so that the differential equations reflect the data points, allowing future predictions to be made. We explore this concept using the shooting method along with the Gauss-Newton method. (Received September 21, 2009)

1056-35-1300 **Nezam Iraniparast*** (nezam.iraniparast@wku.edu), Western Kentucky University, 1906 College Heights Blvd., Bowling Green, KY 42101-1078. *Scattering Due to a Medium Density Change.* Preliminary report.

The scattering of waves in strings with a single change in their constant density is well known. One can also write the solution of the wave equation when there are two changes in the density. We are interested in knowing the analog of these phenomena in solitary waves of kdv type, or in the extensional vibrations of a circular ring or the scattering of waves in a wave guide. (Received September 21, 2009)

1056-35-1327 **Irena Lasiecka** and **Amjad Tuffaha*** (tuffaha@usc.edu), University of Southern California, 3620 South Vermont Ave., KAP 108, Los Angeles, CA 90089. *Bolza boundary control problem for a fluid-structure interaction model.*

We consider a Bolza boundary control problem for a fluid structure interaction model consisting of a linearized Navier-Stokes equation coupled with a dynamic wave equation. The model incorporates convective terms resulting from the linearization of the Navier-Stokes equation around equilibrium. The existence of the optimal control and its feedback characterization via a solution to a Riccati equation is established. The main difficulty is caused by unbounded action of control forces which, in turn, result in Riccati equations with unbounded coefficients and in singular behavior of the gain operator. This class of problems has been recently studied via the so called Singular Estimate Control Systems (SECS) theory. It is shown that the fluid-structure interaction does satisfy the Singular Estimate (SE) condition. This is accomplished by proving that the maximal abstract parabolic regularity is transported via hidden hyperbolic regularity of the boundary traces on the interface. The Singular Estimate permits application of recently developed general theory which implies well-posedness of the feedback synthesis and of the associated Riccati Equation. Moreover, the singularities in the optimal control and in the feedback operator at the terminal time are quantitatively described. (Received September 21, 2009)

1056-35-1337 **Anahit Galstyan*** (agalstyan@utpa.edu), Department of Matrhematics, University of Texas-Pan American, 1201 West University Drive, Edinburg, TX 78539, and **Tamotu Kinoshita** and **Karen Yagdjian**. *Fundamental solutions of the wave equation in the Einstein-de Sitter spacetime.*

In this talk we introduce the fundamental solutions of the wave equation in the Einstein-de Sitter spacetime. The last one describes the simplest non-empty expanding model of the universe. The covariant d'Alambert's operator in the Einstein-de Sitter spacetime belongs to the family of the non-Fuchsian partial differential operators. In this talk we investigate initial value problem for this equation and give the explicit representation formulas for the solutions. The equation is strictly hyperbolic in the domain with positive time. On the initial hypersurface its coefficients have singularities that make difficulties in studying of the initial value problem. In particular, one cannot anticipate the well-posedness in the Cauchy problem for the wave equation in the Einstein-de Sitter spacetime. The initial conditions must be modified to so-called weighted initial conditions in order to adjust them to the equation. We also show the $L_p - L_q$ estimates for solutions. Thus, we have prepared all necessary tools in order to study the solvability of semilinear wave equation in the Einstein-de Sitter spacetime.

This is a joint work with Tamotu Kinoshita (University of Tsukuba, Japan) and Karen Yagdjian(University of Texas-Pan American, U.S.A.). (Received September 21, 2009)

1056-35-1341 **Guoping Zhang***, Department of Mathematics, Morgan State University, 1700 E Cold Spring Lane, Baltimore, MD 21251. *Standing wave solutions of the discrete nonlinear Schrödinger equations with site-dependent nonlinearity.* Preliminary report.

In this talk I will show the existence of infinitely many nontrivial standing wave solutions of the discrete nonlinear Schrödinger equation with the unbounded potential and site-dependent nonlinearity by using the generalized Nehari manifold method. (Received September 21, 2009)

1056-35-1378 **Pierre Garapon*** (pgarapon@stanford.edu), Department of mathematics, Sloan Hall, 450 Serra Mall, Stanford, CA 94305, **Habib Ammari** (ammari@cmapx.polytechnique.fr), Ecole Polytechnique, 91128 Palaiseau, France, and **François Jouve** (jouve@math.jussieu.fr), Laboratoire Jacques Louis Lions, 175-179 rue du chevaleret, 75013 PARIS, France. *Multiscale elasticity imaging.*

Elasticity imaging or elastography is a new medical imaging modality. It consists of applying to an incompressible soft elastic medium a mechanical excitation and retrieving the resulting displacement field in order to assess the mechanical properties of the medium. We use the model of harmonic incompressible elasticity in a bounded inhomogenous medium to model the situation. Using the formalism of integral equations, we derive an asymptotic analysis of the displacement field in presence of a small inclusion. The multiscale behaviour that we observe for the field is our starting point to design a numerical technique to solve the inverse problem and image the elastic modulus of the medium. We discuss the performances of such a numerical technique. (Received September 21, 2009)

1056-35-1388 **Guillaume Bal** (gb2030@columbia.edu), Columbia University, S. W. Mudd Building, Room 206, 500 West 120th Street, New York, NY 10027, and **Wenjia Jing*** (wj2136@columbia.edu), Columbia University, S. W. Mudd Building, Room 200, 500 West 120th Street, New York, NY 10027. *Corrector analysis for homogenization of stationary linear transport equations in random media.*

We consider stationary linear transport equations with highly oscillating optical parameters modeled as stationary random processes of the form $k(\frac{x}{\epsilon}, \omega)$. It is known that as $\epsilon$ goes to zero, the solutions converge to that of the homogenized equation with optical parameters averaged. In this paper we analyze the corrector, i.e., difference between the solutions. We show that: Firstly, as a random variable at each point in the phase space, the rescaled corrector converges in distribution to a Gaussian random variable. Secondly, as a process and with a different scaling, the corrector converges in distribution and weakly to a Gaussian process, which admits explicit stochastic integral representation. The proper scaling depends on the decorrelation rates of the random media, and the second result is obtained with additional assumptions on the structures of the random media satisfied by standard processes like Gaussian process and Poisson point process.

This research is motivated by and finds application in the inverse transport theory, which in turn has applications in medical imaging, geophysical imaging, etc. (Received September 21, 2009)

1056-35-1390 **Dhanapati Adhikari*** (dadhika@math.okstate.edu), Department of Mathematics, Oklahoma State University, Stillwater, OK 74078, and **Chongsheng Cao** and **Jiahong Wu**. *The 2D Boussinesq Equations with vertical viscosity and vertical diffusivity.* Preliminary report.

A fundamental issue concerning Boussinesq equations is whether or not their classical solutions are always global in time. In this talk, we consider the 2D Boussinesq equations with vertical viscosity and vertical diffusivity. We prove conditional global in time regularity results. (Received September 21, 2009)

1056-35-1397 **Wen-Xiu Ma*** (mawx@cas.usf.edu), Department of Mathematics and Statistics, University of South Florida, 4202 E Fowler Avenue, Tampa, FL 33620-5700. *Analytical approaches for solving nonlinear equations.*

There are many direct analytical techniques for solving nonlinear problems, for example, Hirota bilinear method, Wronskian and Casoratian determinant techniques, and Baecklund and Darboux transformations. A general idea behind the existing methods is to decompose nonlinear partial differential equations into integrable ordinary differential equations and then to solve the resulting ordinary differential equations. We wills focus on the transformed rational function method, which provides a systematical and convenient handling of the solution process of nonlinear equations and unifies many existing methods including the tanh-function type methods, the homogeneous balance method, the exp-function method, the mapping method, and the F-expansion type methods. The key point is to search for rational solutions to variable-coefficient ordinary differential equations transformed from given partial differential equations. Applications to higher-dimensional problems show the diversity of exact solutions to nonlinear equations. (Received September 21, 2009)

1056-35-1414 **L. Douglas Poole*** (lpoole@mines.edu), Dept of Mathematical and Computer Sciences, Colorado School of Mines, Golden, CO 80401, and **Willy Hereman** (whereman@mines.edu), Dept of Mathematical and Computer Sciences, Colorado School of Mines, Golden, CO 80401. *Symbolic Computation of Conservation Laws of Nonlinear Partial Differential Equations.*

A method will be presented for the symbolic computation of conservation laws of nonlinear partial differential equations (PDEs) involving multiple space variables and time. Using the scaling symmetries of the PDE, the conserved densities are constructed as linear combinations of scaling homogeneous terms with undetermined coefficients. The variational derivative is used to compute the undetermined coefficients. The homotopy operator is used to invert the divergence operator, leading to the analytic expression of the flux vector.

The method is algorithmic and has been implemented in the syntax of the computer algebra system MATHEMATICA. The software is being used to compute conservation laws of nonlinear PDEs occuring in the applied sciences and engineering. The software package will be demonstrated by computing conservation laws for the Korteweg-de Vries equation which models shallow water waves, the Zakharov-Kuznetsov equation which models ion-acoustic waves in plasmas, and the Khoklov-Zabolotskaya equation which models sound waves in nonlinear media. (Received September 21, 2009)

1056-35-1438 **Daniel t Onofrei*** (onofrei@math.utah.edu), 1126 Michigan Avenue, salt lake city, UT 84105. *Near cloaking defeats the anti-cloak.*

Cloaking theory gained a lot of attention in the recent years in both the physics and the applied mathematics communities. We will present the idea behind the near cloaking scheme recently proposed by Kohn, Onofrei, Vogelius and Weinstein and discuss how this scheme cloaks objects with negative index of refraction as well, thus defeating the anti-cloak structure proposed by Chen, Luo, Ma, and Chan. (Received September 21, 2009)

1056-35-1442 **Joseph E Hibdon, Jr*** (j-hibdon@northwestern.edu), Department of Engineering Science and Applied, Math, 2145 Sheridan Rd., Evanston, IL 60208, and **Moshe Matalon**. *Mechanisms of the Instabilities of Ideal Diffusion Flames.*

We present a study aimed at identifying the mechanisms that cause instabilities in diffusion flames, specifically the onset of oscillations. The configuration adopted is the planar unstrained flame with no bulk flow resulting in an ideal diffusion flame where the reactants reach the reaction sheet purely by diffusion. Analysis allows for unequal non-unity Lewis numbers as well as incomplete combustion. The linear stability problem reduces to solving the generalized eigenvalue problem to examine the onset of oscillations of the reaction sheet. The effect of the instability on the flow field surrounding the reaction sheet is examined for a wide range of parameters including the distinct Lewis numbers associated with the fuel and oxidizer and the initial mixture strength. An increase in the thermal expansion is found to be a stabilizing influence on the onset of oscillations. The dependence of the frequency on the parameters is examined for the planar diffusion flame with one reactant supplied in a uniform stream and the other diffusing against the stream, and is related to experimental results. It is found that the frequency is sensitive to the initial mixture strength of the reactants and the Lewis numbers. (Received September 21, 2009)

1056-35-1449 **Jonathan Luk***, Department of Mathematics, Fine Hall, Washington Road, Princeton, NJ 08540. *Decay Rate for the Linear Wave Equation on a Schwarzschild Black Hole.*

We prove that sufficiently regular solutions to the wave equation $\Box_g \phi = 0$ on the exterior of the Schwarzschild black hole obey the estimates $|\phi| \leq C_\delta v_+^{-\frac{3}{2}+\delta}$ and $|\partial_t \phi| \leq C_\delta v_+^{-2+\delta}$ on a compact region of $r$ and along the event horizon. This is proved with the help of a new vector field commutator that is analogous to the scaling vector field on Minkowski spacetime. This result improves the known decay rates in the region of finite $r$ and along the event horizon. (Received September 21, 2009)

1056-35-1487 **Daniel T Onofrei*** (onofrei@math.utah.edu), 1126 Michigan Avenue, salt lake city, UT 84105. *Active exterior cloaking.*

We will present the ideas behind active exterior cloaking and comment on the advantages/disadvantages of our method with respect to other approaches proposed in the literature. The talk will be focused on the exterior cloaking for electromagnetic guided waves and acoustic waves.

Together with the analysis results, numerical simulations of the cloaking process will be shown. (Received September 21, 2009)

1056-35-1492 **Matthew Rudd*** (mrudd@uidaho.edu), Department of Mathematics, University of Idaho, 300 Brink Hall, Moscow, ID 83844. *Statistics of p-harmonic functions.* Preliminary report.

The mean value property characterizes continuous harmonic functions, and it is natural to wonder if $p$-harmonic functions have analogous statistical descriptions. Some basic calculations suggest that a continuous function $u$ is $p$-harmonic in $\Omega$ if and only if

$$u(x) = (2-p)\,\mathrm{median}\,\{\,u(s)\,\} + (p-1)\,\mathrm{mean}\,\{\,u(s)\,\}$$

at each $x \in \Omega$, where $s \in \partial B(x,r)$ and $B(x,r) \Subset \Omega$. We will report on ongoing work on these ideas and their applications. (Received September 22, 2009)

1056-35-1498 **Chunli Chen*** (clchen@sjtu.edu.cn), Department of Mathematics, Shanghai Jiao Tong University, 800. Dongchuan Rd, Shanghai, 200240, Peoples Rep of China. *The exact solutions of Lund-Regge equation and its soliton surfaces.*

By Darboux transformation, we get one new group of exact solutions of Lund-Regge(LR) equation which describes the motion of some strings. According to Sym's formula and the isomorphism between $R^3$ and $su(2)$, the surfaces can be expressed by a 2×2 matrix in $su(2)$.The analysis form of one soliton surfaces and double soliton surfaces are obtained and the properties of the surfaces also are studied. (Received September 22, 2009)

1056-35-1523 **S. Minerva Venuti*** (swelling@gmu.edu) and **Padmanabhan Seshaiyer** (pseshaiy@gmu.edu). *Modeling, Analysis and Computation of Fluid Structure Interaction Models for Biological Systems.*

This undergraduate research presents mathematical models for the interaction of blood flow through arterial walls which are surrounded by cerebral spinal fluid. The blood pressure on the inner arterial wall is modeled using a Fourier Series approach. The outer part of the arterial wall and the surrounding cerebral spinal fluid will be coupled using appropriate partial differential equations. The fully coupled system will be analyzed using both analytical (Laplace Transforms) and computational (finite difference methods) tools. Both linear as well as nonlinear (geometric and material) models will be considered in this study. Applications of the model studied to intracranial saccular aneurysms will be presented. (Received September 22, 2009)

1056-35-1559 **Dawn A. Lott*** (dlott@desu.edu), Delaware State University, Department of Mathematical Sciences, 1200 North DuPont Highway, Dover, DE 19901, **Auris Henriquez-Fernandez** (auris_hf@hotmail.com), University of Puerto Rico, Rio Piedras, PR, **Bryan Moore** (mooreb23@msu.edu), Michigan State University, East Lansing, MI, **Benjamin Sturdevant** (bsturdevant@wisc.edu), University of Wisconsin, Madison, WI , and **Anjan Biswas** (abiswas@desu.edu), Delaware State University, Dover, DE. *An Analytical and Numerical Study of Optical Soliton Propagation through Photorefractive Media governed by Logarithmic Law Nonlinearity.*

An analytical and numerical study of the Nonlinear Schrödinger's Equation (NLSE) with logarithmic law nonlinearity is performed. Optical soliton are stable wave solutions of the Nonlinear Schrödinger's Equation (NLSE). The focus of this work is the study of the NLSE with the log law nonlinearity. This type of nonlinearity models the propagation of a wave through a photorefractive media. Assuming a traveling wave ansatz, the NLSE is reduced to a second-order, ordinary differential equation (ODE). Stability conditions for this ODE are obtained by performing a linear stability analysis about its critical points. Given specific initial conditions for a Gaussian, the ODE is solved numerically by applying the fifth-order Runge-Kutta Fehlberg method. The final result, the solution of the NLSE with Gaussian ansatz is obtained. The evolution of the pulse is presented in three dimensions. (Received September 22, 2009)

1056-35-1575 **Scott N Armstrong*** (armstrong@math.lsu.edu), Louisiana State University, Department of Mathematics, 303 Lockett Hall, Baton Rouge, LA 70803. *Studying the infinity Laplace equation via a finite difference approximation.*

I will summarize recent research in collaboration with Charles Smart. We show that by slightly modifying infinity subharmonic functions by "maxing over small balls", we obtain subsolutions of a certain finite difference approximation. This allows us to study the infinity Laplace equation by focusing on this finite difference equation, which is simpler to analyze. We obtain new stability, existence, uniqueness, and convergence theorems for the infinity Laplacian, and some very simple new proofs of known results like Jensen's uniqueness theorem. (Received September 22, 2009)

1056-35-1576 **Prince Chidyagwai***, Dept. of Computational & Applied Mathematics, 6100 Main St. - MS 134, Houston, TX 77005, and **Beatrice Riviere**. *On the solution of the coupled Navier-Stokes and Darcy equations.*

We consider a model for the coupled Navier-Stokes and Darcy equations. The Navier-Stokes equations are used to model flow in a free fluid flow domain and Dary's law for the flow in a porous media domain. We will show the existence and uniqueness of a weak solution for the coupled problem. We will propose a numerical method that uses continuous finite elements in the incompressible flow region and discontinuous finite elements in the porous media domain. Numerical results to illustrate the nature of the flows generated and to verify theoretical convergence rates will also be presented. (Received September 22, 2009)

1056-35-1579 **Santiago P. Fortes*** (santiago@math.lsu.edu), 3450 Nicholson Drive, Apt. 2020, Baton Rouge, LA 70802, and **Robert P. Lipton** and **Stephen P. Shipman**. *Sub-Wavelength Plasmonic Crystals: Dispersion Relations and Effective Properties.*

We obtain a convergent power series representation for the first branch of the dispersion relation for sub-wavelength plasmonic crystals consisting of plasmonic rods with frequency-dependent dielectric permittivity embedded in a host medium with unit permittivity. (Received September 22, 2009)

1056-35-1606 **Taixi Xu*** (txu@spsu.edu), Southern Polytechnic State University, 1100 S Marietta Parkway, Marietta, GA 30060. *Peakons of b-family and Qiao Equations.* Preliminary report.

In this paper, we try to find all possible peakons of b-family and Qiao's equations. When b=2 and b=3 we have the Camassa Holm's equation and DP equation, respectively. The formula for general peakons are given, and some special peakons are analyzed. (Received September 22, 2009)

1056-35-1615 **Jaffar Ali*** (jahameed@fgcu.edu), #450, Library, Florida Gulf Coast University, 10501 FGCU Blvd. S., Fort Myers, FL 33965, and **Ratnasingham Shivaji** (shivaji@ra.msstate.edu), Department of Mathematics, Mississippi State University, Mississippi State, MS 39759. *Multiple positive solutions for a class of p-q-Laplacian systems with multiple parameters and combined nonlinear effects.*

Consider the system

$$\begin{cases} -\Delta_p u &= \lambda_1 f(v) + \mu_1 h(u), \text{ in } \Omega \\ -\Delta_q v &= \lambda_2 g(u) + \mu_2 \gamma(v), \text{ in } \Omega \\ & u = 0 = v, \text{ on } \partial\Omega \end{cases}$$

where $\Delta_s z = div(|\nabla z|^{s-2}\nabla z); s > 1, \lambda_1 > 0, \lambda_2 > 0, \mu_1 \geq 0$ and $\mu_2 \geq 0$ are parameters and $\Omega$ is a bounded domain in $R^n$ with smooth boundary $\partial\Omega$. For some classes of non-negative monotone functions $f, g, h$ and $\gamma$ which satisfy

$$\lim_{x\to\infty} \frac{f(M[g(x)]^{1/q-1})}{x^{p-1}} = 0, \ \forall M > 0,$$

$\lim\limits_{x\to\infty} \dfrac{h(x)}{x^{p-1}} = 0$ and $\lim\limits_{x\to\infty} \dfrac{\gamma(x)}{x^{q-1}} = 0$, we discuss the existence of multiplicity of positive solutions for certain range of parameters $\lambda_1, \mu_1, \lambda_2$ and $\mu_2$. We use the method of sub- and super-solutions to establish our results. (Received September 22, 2009)

1056-35-1617 **Avis A Foster*** (afoster9@gmu.edu), 4400 University Dr., STI, Department of Mathematical Sciences, George Mason University, Fairfax, VA 22030, and **Daniel M Anderson**, **S. Minerva Venuti** and **Padmanabhan Seshaiyer**. *Numerical Modeling and Analysis of Fluid Structure Interaction in Biological Systems.* Preliminary report.

This research work expands on an analytical solution for a mathematical model of blood flow through an artery, and the blood's interaction with the arterial wall and the surrounding cerebral spinal fluid. A mathematical model is developed using a wave equation and boundary conditions derived from a combination of Fourier series, a spring-mass equation, and a simplified Navier-Stokes Equation. The coupled system is solved via a method of lines numerical approach that predicts the mechanics of the arterial wall. The resultant model was validated against the analytical solution and analyzed for application to cerebral brain aneurysms. Influence of various model parameters is also investigated. (Received September 22, 2009)

1056-35-1626 **Charles K Smart*** (smart@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94720-3840. *Numerical methods for the infinity Laplace equation.*

I will describe research developing numerical methods for the infinity Laplace equation. I will construct a provably convergent scheme with a high order rate of convergence. The scheme is a hybrid of a finite element method and monotone finite difference scheme and is motivated by my recent work with Scott Armstrong. Time permitting, I will discuss generalizations to other equations. (Received September 22, 2009)

1056-35-1628 **Karen Yagdjian*** (yagdjian@utpa.edu), Department of Matrhematics, University of Texas-Pan American, 1201 West University Drive, Edinburg, TX 78539. *The blowup for the semilinear Klein-Gordon equation in de Sitter spacetime.*

In this talk we present the blowup phenomena for the solutions of the semilinear Klein-Gordon equation $\square_g \phi - m^2\phi = -|\phi|^p$ with the small mass $m \le n/2$ in de Sitter spacetime with the metric $g$. We prove that for every $p > 1$ large energy solutions blow up, while for the small energy solutions we give a borderline $p = p(m,n)$ for the global in time existence. The consideration is based on the representation formulas for the solution of the Cauchy problem and on some generalizations of Kato's lemma. (Received September 22, 2009)

1056-35-1631 **Jintae Kim*** (j.kim.tu@gmail.com). *Existence of time periodic solutions of non-linear wave equations.*

The existence of time periodic solutions of nonlinear wave equations

$$u_{tt} - \Delta_n u + \big(\frac{n-1}{2}\big)^2 u = g(u) - f(t,x), \quad (t,x) \in S^1 \times S^n,\ n > 1$$

on $n$-dimensional spheres is considered. We study the case where $g(u)$ is superliner and not an odd function, so that the corresponding functional is not symmetric. Using minimax arguments, comparison principles and Morse theory, the existence of infinitely many time periodic solutions is obtained. (Received September 22, 2009)

1056-35-1634 **Roger Thelwell*** (thelwerj@jmu.edu), Dept. of Math and Stats, MSC 1911, James Madison University, Harrisonburg, VA 22807. *Reinventing the Wheel!*

The chaotic waterwheel is a well studied and fairly well understood problem in dynamical systems literature. In brief, a wheel with punctured cups equally spaced around a wheel driven by a single source of water will display chaotic behavior by tuning two parameters: flow rate and friction. This talk will begin with an introduction to the physical setup of the waterwheel and the mathematical analyses.

Students at James Madison University were the first, to our knowledge, to do either a mathematical analysis or build a prototype of a sand-driven wheel. How does sand behave differently than water? How does this impact the mathematics and the mathematical conclusions? Be prepared to be surprised by the counterintuitive conclusions of this talk. (Received September 23, 2009)

1056-35-1681 **J Mahmoud Anabtawi*** (manabtawi@aus.edu), Department of Mathematics and Statistics, American University of Sharjah, P.O. Box 26666, Sharjah, 26666, United Arab Emirates. *LYAPUNOV FUNCTIONALS VS LYAPUNOV FUNCTIONS IN STABILITY ANALYSIS FOR STOCHASTIC PARABOLIC DIFFERENTIAL EQUATIONS OF ITO TYPE.* Preliminary report.

In this work, Lyapunov like-functionals vs using Lyapunov like functions coupled with the comparison principle are utilized to establish sufficient conditions for practical stability criteria of the equilibrium state of a hybrid stochastic parabolic differential equation of Ito type. The main objective of the study is to compare between the two approaches and characterize the effect of each technique on stability analysis. A concluding remark will highlight the major differences between the two approaches for this specific type of differential equations with a diffusion term. (Received September 22, 2009)

1056-35-1722 **Gino Biondini***, Math Dept., SUNY at Buffalo, Buffalo, NY 14260, and **Guenbo Hwang**. *Solitons, boundary value problems and a nonlinear method of images.*

We discuss the solution of initial-boundary-value problems (IBVPs) for the nonlinear Schroedinger (NLS) and its integrable discrete analogue, the Ablowitz-Ladik (AL) system. We consider such equations on semi-infinite spatial domains and with linearizable boundary conditions (BCs). We show how such kinds of IBVPs can be effectively solved by extending the solution to an infinite domain and using the inverse scattering transform (IST) machinery available for the corresponding initial value problem (IVP). We then discuss the symmetries in the discrete and continuous spectrum induced by the BCs, and we use these symmetries to characterize the soliton solutions. In particular, we show that, for both the NLS equation and the AL system, the reflection at the boundary experienced by the solitons is due to the presence of an equal number of mirror solitons located beyond the boundary of the physical domain. These results provide a nonlinear analogue to the method of images for linear partial differential equations. (Received September 22, 2009)

1056-35-1783 **D. Palaniappan*** (palaniap@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843-3368. *Computation of Green's functions via successive image theory.*

The use of Green's functions in mathematics, engineering, physics, and other related fields is well explained in the literature. However, the computation of Green's functions for a geometry of an arbitrary shape is still a difficult task and as a consequence not many explicit forms are known. In this presentation, a systematic technique leading to the computation of Green's functions for Laplace and biharmonic equations involving intersecting circular/spherical boundaries will be discussed. This technique, which uses successive image theory, yields exact, closed forms of such functions with Dirichlet, Neumann and mixed type boundary conditions. Some analytic forms for the Green's functions which have applications in electro- & magnetostatics and inviscid/viscous hydrodynamics will be shown to exemplify the efficacy of our approach. (Received September 22, 2009)

1056-35-1793 **Betul Orcan*** (borcan@math.utexas.edu), Department of Mathematics, University of Texas at Austin, Austin, TX. *Homogenization of The Laplace Equation with Oscillating Stationary Ergodic Free Boundary.* Preliminary report.

We will analyze the behavior, as $\epsilon \to 0$, of the family of 1-phase free boundary problems for the Laplace Equation which has highly oscillatory random free boundary.

$$\begin{cases} \triangle u_\epsilon = 0 & \text{in } \Omega(u_\epsilon) \\ u_\epsilon = 0, |\nabla u_\epsilon|^2 = f(\frac{x}{\epsilon}, w) & \text{on } \partial\Omega(u_\epsilon) \end{cases} \tag{1}$$

where $\Omega(u) = \{x | \; u(x) > 0\}$, $f$ is a strictly positive, bounded, continuous function, and the process is stationary ergodic. We will prove that for the least supersolution $u_\epsilon$ of the equation, there exists a continuous function $u$ such that, as $\epsilon \to 0$, $u_\epsilon(x, w) \to u(x, w)$. Moreover, $u$ is the least supersolution of a free boundary problem which has an appropriate slope, independent of $w$, in each normal direction $\nu$ on the free boundary. Our study will enable us to extend the study of L. Caffarelli, K. Lee and A. Mellet, (2007);Flame Propagation in 1-Dim Stationary Ergodic Media, to $R^2$. Also, we will use the result of this study to generalize the study of L. Caffarelli and K. Lee, (2007); Homogenization of Oscillating Free Boundaries: The Elliptic Case, to the random case. (Received September 22, 2009)

1056-35-1828 **Emek Kose Can*** (eksecan@lmu.edu), Loyola Marymount University, Department of Mathematics, 1 LMU Drive University Hall Suite 2700, Los Angeles, CA 90045, and **Ronald Perline**, Drexel University Mathematics Department, 206 Korman Hall, 3141 Chestnut St., Philadelphia, PA 19104. *Micromirror Method For Catadioptric Sensor Design.*

We present a novel method for design of imaging systems called catadioptric sensors, which consist of a micromirror array, a conventional asymmetric mirror and an orthographic camera. The main problem of catadioptric sensor design is constructing a mirror for a given projection which generically does not have a solution. We overcome limitations of single-mirror catadioptric sensors by designing the camera projection as well as the mirror surface. This construction allows us to exactly achieve any desired projection, not only orthographic or perspective. The key in finding the mirror surface and the camera projection is, constructing a vector field normal to the sought-after surface. For the surface to exist, the normal vector field has to be integrable. The integrability condition for the vector field is provided by Frobenius integration theorem for differential forms. The integrability condition yields a system of first order quasilinear partial differential equaitons, whose numerical solution is the camera projection. Computing the mirror surface is done by numerically integrating the normal vector field. We present our results for four different systems where error for both projection and mirror surface are very promising. (Received September 22, 2009)

1056-35-1845 **Adem Cakmak*** (cakmak@ohio.edu), OHIO UNIVERSITY LANCASTER, 1570 GRANVILLE PIKE, Lancaster, OH 43130-1037. *Analysis of nonlinear Darcy-Forchheimer flows in porous media.*

This work is focused on certain theoretical aspects of nonlinear non-Darcy flows in porous media, and their application in reservoir and hydraulic engineering. The goal of this work is to develop a mathematically rigorous framework to study the dynamical processes associated to all three classical nonlinear Forchheimer laws for slightly compressible fluids. In our approach each anisotropic Forchheimer equation is replaced by a constitutive equation which relates the velocity vector field with the pressure gradient in a non-linear way. This allows reducing the original system of equations to one degenerate parabolic equation for the pressure only. It is shown that under some hydrodynamic and thermodynamic constraints there exists stable equilibrium: pseudo-steady state regime for the Forchheimer flows in porous media, which serves as a global attractor for wide classes of the flows yielding an alternative time independent computation of productivity index/diffusive capacity of a well. (Received September 22, 2009)

1056-35-1970 **Guillaume Bal*** (gb2030@columbia.edu), 500 W 120th St, New York, NY 10027. *Inverse diffusion with internal measurements.*

Photoacoustics is a novel medical imaging modality combining the large contrast of optical waves with the high resolution of acoustic waves. In somewhat idealized settings, the inverse problem of photoacoustics may be recast as an inverse diffusion problem with internal data. I will present recent theoretical results on the reconstruction of the optical parameters (the parameters of interest) from internal data and on the stability of such reconstructions. (Received September 22, 2009)

1056-35-1972 **Phillip D Whitman*** (pwhitman@math.princeton.edu), 11 Lawrence Dr # 105, Princeton, NJ 08540. *Uniqueness of solutions to linear wave equations.* Preliminary report.

Recent work on black hole uniqueness by Ionescu, Klainerman, Alexakis and others has led to increased interest in the problem of prescribing data on the event horizons of black holes for solutions to linear wave equations. Ionescu and Klainerman show that if we require that the solution be stationary on any Kerr spacetime, then we have uniqueness throughout the entire domain of outer communication. Additionally, if we require that the solutions be analytic, we will again have uniqueness throughout the domain of outer communication. However, we expect nonuniqueness (in general) of smooth, nonstationary (and not analytic) solutions. We will discuss recent work concerning unique continuation for linear wave equations on the Schwarzschild spacetime and Minkowski space. (Received September 22, 2009)

1056-35-1977 **Yi Li*** (yi-li@uiowa.edu), Department of Mathematics, University of Iowa, and Xian Jiaotong University, Iowa City, IA 52242, and **Shuangjie Peng** (sjpeng@mail.ccnu.edu.cn), School of Mathematics and Statistics, Central China Normal University, Wuhan, 430079, Peoples Rep of China. *Multiple Solutions to an Elliptic Problem Related to Vortex Pairs.*

We consider the problem $-\Delta u = \lambda(u-\varphi)_+^{p-1}, x \in \Omega, u|_{\partial\Omega} = 0$, where $\Omega$ is a bounded domain in $\mathbb{R}^N$, $\varphi$ is a positive harmonic function in $\overline{\Omega}$.

This problem is related to steady vortex pairs in an ideal fluid. Under the following condition: $\varphi$ has $k$ ($k \geq 1$) strictly local minimum points $\bar{z}_1, \cdots, \bar{z}_k \in \partial\Omega$, we are able to prove the existence of a solution pair $(u_\lambda, A_\lambda)$ satisfying that the "vortex core" (where $u_\lambda > \varphi$) $A_\lambda$ has exactly $k$ components $A_{\lambda,j}$, $j = 1, \cdots, k$ which shrink to the points $\bar{z}_1, \cdots, \bar{z}_k$ respectively as $\lambda \to +\infty$. Moreover, $A_{\lambda,j}$ is approximately a ball with very precise estimates of $z_j - \bar{z}_j$ and $diam(A_{\lambda,j})$. (Received September 22, 2009)

1056-35-1982 **Yi Li*** (yi-li@uiowa.edu), Department of Mathematics, University of Iowa, and Xian Jiaotong University, Iowa City, IA 52242, and **Baishun Lai** (laibaishun@yahoo.com.cn), Departmen of Mathematics, Hunan Normal University, and Henan University, Changsha, Peoples Rep of China. *Stability of the Positive Steady States for a Nonhomogeneous Semilinear Parabolic Problem.*

This talk is contributed to the Cauchy problem

$$\begin{cases} \frac{\partial u}{\partial t} = \Delta u + K(|x|)u^p + \mu f(|x|) \;\; in \; R^n \times (0,T), \\ u(x,0) = \varphi(x) \;\; in \; R^n. \end{cases} \tag{1}$$

The monotonicity/separation property and stability of the positive radial steady states, which are positive solutions of

$$\Delta u + K(|x|)u^p + \mu f(|x|) = 0,$$

are discussed, $\mu$ is some positive constant, $0 \leq f \in C^1(R^n \backslash \{0\})$, $K(x)$ is a given local Hölder continuous function in $R^n \backslash \{0\}$, and $\varphi$ is a bounded non-negative continuous function in $R^n$. (Received September 22, 2009)

1056-35-1987 **John Bernard Gonzalez*** (`johngonz@gmail.com`), 28 Forest St. #1, Somerville, MA 02143. *Solutions of the Nonlinear Schrödinger Equation with Prescribed Asymptotics at Infinity.* Preliminary report.

We prove local existence and uniqueness of solutions for the one-dimensional nonlinear Schrödinger (NLS) equations $iu_t + u_{xx} \pm |u|^2 u = 0$ in classes of smooth functions that admit an asymptotic expansion at infinity in decreasing powers of $x$. We show that an asymptotic solution differs from a genuine solution by a Schwartz class function which solves a generalized version of the NLS equation. The latter equation is solved by discretization methods. The proofs closely follow previous work done by the author and others on the Korteweg-De Vries (KdV) equation and the modified KdV equations. (Received September 22, 2009)

1056-35-2005 **Yifeng Yu*** (`yyu1@math.uci.edu`), Department of mathematics, University of California at Irvine, Irvine, CA 92697-3875. *A remark on $C^2$ infinity harmonic functions.*

In this talk, we will show that any nonconstant, $C^2$ solution of the infinity Laplacian equation $u_{x_i} u_{x_j} u_{x_i x_j} = 0$ can not have interior critical points. This result was first proved by Aronsson when the dimension is 2 and Evans for $C^4$ solutions in any dimension. (Received September 22, 2009)

1056-35-2032 **Haewon Lee*** (`hlee@dillard.edu`), Dillard University, Division of Natural Sciences, 2601 Gentilly Blvd., New Orleans, LA 70122, and **Peter Frempong-Mireku** (`pfmireku@dillard.edu`), Dillard University, Division of Natural Sciences, 2601 Gentilly Blvd., New Orleans, LA 70122. *Nonautonomous Fractional Integrodifferential Equations with Nonlocal Initial Conditions.*

In this paper we study the existence of mild solutions to nonautonomous fractional integrodifferential equations with nonlocal initial conditions:

$$\begin{cases} D^\alpha u(t) + A(t)u(t) = f(t, u(t)) + \displaystyle\int_0^t q(t-s)h(s, u(s))ds, \quad t > 0, \quad 0 < \alpha \leq 1, \\ u(0) + g(u) = u_0. \end{cases}$$

The approach relies on the use of compactness methods and fixed-point techniques. (Received September 23, 2009)

1056-35-2037 **Catherine Lebiedzik*** (`ar6554@wayne.edu`), Wayne State University, Department of Mathematics, 1150 Faculty/Administration Building, Detroit, MI 48202. *Optimal control of a thermoelastic structural acoustic model.*

We consider point control of a structural acoustic model with thermoelastic effects. The key feature of this paper is that the two-dmensional plate modeling the active wall of the acoustic chamber has clamped boundary conditions. For this case a new optimal regularity result has recently become available. Using this new result for the plate alone, we derive a sharp regularity result for the overall coupled system of wave and thermoelastic plate equations. This allows for the study of optimal control of the coupled system. (Received September 22, 2009)

1056-35-2086 **Changzheng Qu*** (`czqu@nwu.edu.cn`), Department of Mathematics, Northwest University, Xi'an, Shaan Xi 710069, Peoples Rep of China. *Integrable systems and invariant geometric flows in similarity and projective geometries.*

In this talk, the relationship between invariant geometric flows and integrable systems is discussed. It is shown that a couple of integrable integrable equations arise from the curve flows in similarity and projective geometries. The Backlund transformations to the integrable equations are obtained by using the geometric flows. (Received September 23, 2009)

1056-35-2120 **Vasile Staicu*** (`vasile@ua.pt`), Department of Mathematics, University of Aveiro, Campus Universitario de Santiago, 3810-193 Aveiro, Portugal. *Multiple solutions for superlinear p-Laplacian Neumann problems.*

We consider a nonlinear Neumann problems driven by the p-Laplacian differentialoperator with a p-superlinear non-linearity. Using minimax methods we show that the problem have five nontrivial smooth solutions, two positive, two negativeand the fifth nodal. In the semilinear case (p=2), using Morse theory, we produce a second nodal solution (for a total of six nontrivial smooth solutions). (Received September 23, 2009)

# 37 ► Dynamical systems and ergodic theory

1056-37-8 **Amie Wilkinson***, Department of Mathematics, Northwestern University, Evanston, IL.
*Chaos and symmetry in partially hyperbolic systems.*

Partially hyperbolic dynamical systems arise in a variety of classical contexts, in systems of both algebraic and geometric origin. These systems are subject to a range of symmetries and at yet are typically chaotic and highly unpredictable in their long-term behavior. In this talk I will survey results about partially hyperbolic systems and discuss the interplay between the mechanisms behind both chaos and symmetry, which also lead to various rigidity phenomena. (Received April 08, 2009)

1056-37-45 **J. D. Mireles-James*** (jjames@math.utexas.edu), Department of Mathematics, 1 University Station C1200, Austin, TX 78712-0257, and **Hector Lomeli**. *Computation of Heteroclinic Arcs for Diffeomorphisms of* $\mathbb{R}^3$.

Let $f$ be a diffeomorphism of $\mathbb{R}^3$ with hyperbolic fixed points $p_1$ and $p_2$. Suppose that $p_1$ has two dimensional unstable, and $p_2$ two dimensional stable manifold. If $W^u(p_1)$ and $W^s(p_2)$ intersect transversally at a point $q$, then the orbit of $q$ is homoclinic from $p_1$ to $p_2$.

By transversality the intersection at $q$ is locally a one dimensional arc $\gamma \subset W^u(p_1) \cap W^s(p_2)$ through $q$. It follows that if $q' \in \gamma$, then $q'$ is heteroclinic as well. We give a method for computing arbitrarily high order polynomial expansions of the arc $\gamma$, and apply the method to the Volume Preserving Henon Family.

The idea is to express $\gamma$ as a zero of a functional equation, which is solved via a Newton scheme. A feature of the method is that the arcs, as well as the stable and unstable manifolds, are computed quickly with very high precision. A typical computation takes minutes and results in polynomial approximations of the desired manifolds which are accurate to within ten to fifty multiples of machine epsilon. The method applies to difference equations which can be expressed as diffeomorphisms of $\mathbb{R}^3$. (Received July 10, 2009)

1056-37-103 **Aaron Hoffman*** (ah1@math.bu.edu), 111 Cummington St., Boston, MA 02215.
*Scattering of solitary waves in the Fermi-Pasta-Ulam lattice.* Preliminary report.

We study the interaction of small amplitude, long wavelength solitary waves in the Fermi-Pasta-Ulam model with general nearest-neighbor interaction potential. We establish global-in-time existence and stability of counter-propagating solitary wave solutions. These solutions are close to the linear superposition of two solitary waves for large positive and negative values of time; for intermediate values of time these solutions describe the interaction of two counter-propagating pulses. These solutions are stable with respect to perturbations in$\ell^2$ and asymptotically stable with respect to perturbations which decay exponentially at spatial $\pm\infty$. In addition, we establish the existence of asymptotic two-soliton states and report progress on the interaction of three or more waves. (Received July 27, 2009)

1056-37-137 **Mohammad Javaheri*** (mohammad.javaheri@trincoll.edu), 300 Summit St, Department of Mathematics, Trinity College, Hartford, CT 06106. *Semigroups of matrices with dense orbits.* Preliminary report.

We prove that for any $n \geq 1$ there exist $n \times n$ matrices $A$ and $B$ such that for any vector $x \in \mathbb{R}^n$ with a nonzero first component, the orbit of $x$ under the action of the semigroup generated by $A$ and $B$ is dense in $\mathbb{R}^n$. As a corollary, we prove that for a large set of diagonal matrices $A$ and $B$ and any vector $V$ with nonzero entries, the orbit of any vector under the semigroup generated by the affine maps $x \to Ax + V$ and $x \to Bx$ is dense in $\mathbb{R}^n$.
(Received July 30, 2009)

1056-37-261 **Chihchien Yu*** (lyu@uafortsmith.edu), PO Box 3649, 5210 Grand Avenue, Fort Smith, AR 72903. *Conditions for the Existence of a Steady State Solution for a Competition System of Plankton Population.*

I use topological methods to analyze biological models in my research. I examined a model of competing system of plankton populations. The populations are modeled by a system of parabolic PDE's. My equation is similar but not the same as the reaction-diffusion equations. The similar part is that I am dealing with almost the same equation and the different part is that I have to deal with new boundary conditions. I established conditions for a steady state solution for the single species case. I can generalize the necessary conditions to the n-species case, but the sufficient condition is much harder. I use numerical simulations to help me to find the solution.
(Received August 21, 2009)

1056-37-293 **Salisu Mohammed Garba*** (garba@cc.umanitoba.ca), Department of Mathematics, 342 Machray Hall, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada. *Mathematical Analysis of Dengue Treatment Model with Variable Viral Load.*

A deterministic model for the transmission dynamics of dengue, which accounts for its viral load variability upon infection, is designed and rigorously analyzed. The model, consisting of mutually-exclusive epidemiological compartments representing the human and vector dynamics, has a locally-asymptotically stable, disease-free equilibrium (DFE) whenever the associated reproduction number (Ro) is less than unity. It is shown, using a Lyapunov function and LaSalle Invariance Principle that the DFE of the model, in the absence of dengue-induced mortality, is globally-asymptotically stable whenever the threshold is less than unity. Using a Krasnoselskii sublinearity trick, it is shown that the associated unique endemic equilibrium is locally-asymptotically stable when it exists. Various treatment strategies based on the use of present (limited) control measures are considered. Numerical simulations of the model show that for high treatment rates, a universal strategy, with high level of effectiveness, can lead to dengue elimination in a community. (Received August 26, 2009)

1056-37-565 **Alon Levy*** (levy@math.columbia.edu), Department of Mathematics, Columbia University, Room 509, Mail Code 4406, New York, NY 10027. *Rationality of the Space of Morphisms on $\mathbb{P}^1$.*

For every integer $d > 1$, we may define the space of morphisms from $\mathbb{P}^1$ to itself of degree $d$; this space is parametrized by monomials of degree $d$, and is an affine open subset of $\mathbb{P}^{2d+1}$. It has an action by PGL(2) induced by the conjugation action of PGL(2) on $\mathbb{P}^1$. The quotient of the action parametrizes dynamical systems on $\mathbb{P}^1$ up to coordinate change. In this talk we prove that the quotient is rational for all $d$, generalizing previous results showing that when $d = 2$, the quotient is isomorphic to $\mathbb{A}^2$. (Received September 12, 2009)

1056-37-656 **Mrinal Kanti Roychowdhury*** (roychowdhurymk@utpa.edu), Dept of Mathematics, UTPA, 1201 West University Drive, Edinburg, TX 78539. *Gibbs measure and the quantization dimension function.*

As a mathematical topic 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 function at which the specified measure of the error goes to zero as $n$ increases. Recently, in a very few cases it has been shown that quantization dimension also has a relationship with the temperature function arising in thermodynamic formalism.

In this talk I will show the quantization dimension function and its relationship with the temperature function for the image measure of Gibbs measure on the one-sided shift dynamical system on the limit set generated by a set of contractive similarities. (Received September 15, 2009)

1056-37-669 **Patrick Ingram*** (pingram@math.uwaterloo.ca), Department of Pure Mathematics, University of Waterloo, Waterloo, Ontario N2l 3G1, Canada. *Multipliers of periodic cycles for cubic polynomials.*

The moduli space of cubic polynomials with a marked point of period $N$ is a 2-dimensional algebraic variety, and admits a natural fibration by the multiplier map. We'll look at the geometry of the generic fiber, and discuss the existence of sections of the fibration. The case $N = 2$ is particularly interesting, and we will describe all sections of the base extension of this surface corresponding to making the multiplier an $m$th power (for arbitrary $m$). (Received September 15, 2009)

1056-37-693 **Hassan M Fathallah-Shaykh*** (hfathall@uab.edu), 1020 Faculty Research Tower, 1530 3rd Avenue S, Birmingham, AL 35294, and **Jerry L Bona** (bona@math.uic.edu). *Model of The Drosophila Circadian Clock: Loop Regulation and Transcriptional Integration.*

Circadian clocks influence key features of daily living including the timing of sleep, awakening and feeding. Eukaryotic circadian clocks include interconnected positive and negative feedback loops. The CLOCK-CYCLE dimer (CLK-CYC) and its homolog, CLK-BMAL1, are key transcriptional activators of central components of the Drosophila and mammalian circadian networks, respectively. In Drosophila, negative loops include period-timeless and vrille; positive loops include par domain protein 1. Clockwork Orange (CWO) is a recently discovered negative transcription factor with unusual effects on period, timeless, vrille, and par domain protein 1. To understand the actions of this protein, we introduced a new system of ordinary differential equations to model regulatory networks. The model is faithful in the sense that it replicates biological observations. CWO loop-actions elevate CLK-CYC; the transcription of direct targets responds by integrating opposing signals from CWO and CLK-CYC. Loop regulation and integration of opposite transcriptional signals appear to be central mechanisms as they also explain paradoxical effects of period gain-of-function and null mutations. (Received September 16, 2009)

1056-37-717 **Firas Y Hindeleh** (hindelef@gvsu.edu), 1 Campus Dr., Allendale, MI 49401, and **Jessica R Sears*** (searsj@mail.gvsu.edu), 4378 Pierce, Allendale, MI 49401. *The Fractal Beauty of Byzantine Music.*

The songs found in Byzantine music posses both audible and mathematical beauty. The purpose of this talk is to study one representative song from each of the eight tones in Byzantine music and demonstrate that each one exhibits a fractal relation between the Musical Instrument Digital Interface (MIDI) frequencies of successive notes for a given note interval. (Received September 16, 2009)

1056-37-793 **Sebastian M Marotta*** (smarotta@pacific.edu), Department of Mathematics, University of the Pacific, 3601 Pacific Avenue, Stockton, CA 95211, and **David Fried** and **Rich Stankewitz**. *Dynamics of semigroups of Moebius transformations.* Preliminary report.

We study the dynamics of semigroups of Moebius transformations on the Riemann sphere. We discuss the topology of the invariant structures that these systems generate, namely, their Fatou and Julia sets and attractors. The theory presents natural connections between the dynamics of rational functions, rational semigroups, and Moebius groups. We illustrate their differences and interactions with examples. In particular, we consider a one-parameter family of Moebius semigroups that originated from a random dynamics variant of the Fibonacci sequence 1, 1, 2, 3, 5, 8, 13, 21, .... The relationship these semigroups, and corresponding groups, bear to the well studied Riley groups is also investigated. (Received September 17, 2009)

1056-37-806 **Youssef Naim Raffoul*** (youssef.raffoul@notes.udayton.edu), Department of Mathematics, University of Dayton, Dayton, OH 45469-2316, and **Joan Hoffacker**, Department of Mathematical sciences, Clemson, SC 29634. *Positive periodic solutions of functional differential equations on time scales and population models.*

In this paper, we employ Krasnosel'skii's fixed point theorem for cones to study the existence of positive periodic solutions to a system of infinite delay equations, $x^{\Delta}(t) = A(t)x^{\sigma}(t) + f(t, x_t)$ We give two general theorems and establish new periodicity conditions for several population growth models.
(Received September 17, 2009)

1056-37-820 **Robert G. Niemeyer*** (niemeyer@math.ucr.edu), 900 Big Springs Rd., Surge Bldg, Math Department, Riverside, CA 92521, and **Michel L. Lapidus** (lapidus@math.ucr.edu), 900 Big Springs Rd., Surge Bldg, Math Department, Riverside, CA 92521. *Towards billiards of the Koch snowflake.* Preliminary report.

In this talk, we shall demonstrate significant analytical and experimental evidence suggesting the existence of periodic orbits of the Koch snowflake billiard. In addition, we outline exactly how we propose to demonstrate the existence of periodic orbits and give a major consequence in the form of an analogue to the Veech Dichotomy for Rational Billiards. (Received September 17, 2009)

1056-37-977 **Cecilia Gonzalez Tokman*** (cecilia@math.umd.edu), Department of Mathematics, Mathematics Building, University of Maryland, College Park, MD 20742-4015. *Approximating invariant densities of metastable systems.*

We consider a piecewise smooth expanding map of the interval possessing two invariant subsets of positive Lebesgue measure, and hence two ergodic absolutely continuous invariant probability measures (ACIMs). When this system is perturbed slightly to make the invariant sets merge, we describe how the ACIM of the perturbed maps can be approximated in terms of the initial ergodic ACIMs, by finding their limit as the size of the perturbation approaches zero. (This is a joint work with B. Hunt and P. Wright) (Received September 19, 2009)

1056-37-1030 **Jon Jacobsen*** (jacobsen@math.hmc.edu), Math Department, Harvey Mudd College, Claremont, CA 91711. *Experiments in the Classroom.*

Physical experiments that illustrate mathematical concepts can be remarkably effective pedagogical tools. They provide an opportunity to connect equations, numerics, and the physical world in a powerful way. In this talk we share several experiments used throughout the undergraduate curriculum at Harvey Mudd College in courses such as differential equations (ODE and PDE), dynamical systems, and numerical analysis. (Received September 20, 2009)

1056-37-1039 **Elizabeth D Russell*** (elizabeth.russell@usma.edu), Department of Mathematical Sciences, United States Military Academy, West Point, NY 10996. *Complex Dynamics and Symbolic Dynamics.*

We study the dynamics of a family of rational maps, demonstrating the presence of Cantor sets of point components in the Julia set of such a map via symbolic dynamics. (Received September 20, 2009)

1056-37-1073 **Nitsan Ben-Gal*** (bengal@dam.brown.edu), 182 George Street, Providence, RI 02912. *Asymptotics of Grow-Up Solutions and Global Attractors for Slowly Non-Dissipative PDEs.* Preliminary report.

We present recent results on the asymptotics of solutions to semilinear parabolic PDEs with linearly growing nonlinearities. We discuss extensions of inertial manifold techniques to a class of slowly non-dissipative dynamical systems and combine them with nodal property and Conley index methods to provide a complete solution to the Connection Problem and an explicit decomposition of the unbounded attractor for such systems. Furthermore, we show that the unbounded attractor for a slowly non-dissipative PDE is the limit of the global attractor of a corresponding dissipative PDE which limits to the original equation. (Received September 20, 2009)

1056-37-1187 **Christopher F Novak*** (cfnovak@umd.umich.edu), Department of Mathematics and Statistics, University of Michigan-Dearborn, 4901 Evergreen Rd., Dearborn, MI 48128. *One-parameter interval exchange actions.*

The space $\mathcal{E}$ of interval exchange maps on the unit interval is a group under composition. When endowed with a natural topology, $\mathcal{E}$ is given the structure of a topological group. A complete classification of one-parameter interval exchange actions (continuous group homomorphisms $\mathbb{R} \to \mathcal{E}$) is given. In particular, it is shown that any such action is conjugate in $\mathcal{E}$ to an action by disjointly supported restricted rotations. (Received September 21, 2009)

1056-37-1206 **Laura DeMarco*** (demarco@math.uic.edu), Department of Mathematics, University of Illinois at Chicago, 851 S Morgan St (M/C 249), Chicago, IL 60607, and **Matt Baker**, Georgia Institute of Technology. *Preperiodic points: from algebraic to complex.*

We combine analytic and arithmetic techniques to study the dynamics of complex polynomials. For quadratic polynomials $z^2 + c$, our main result is that the set of parameters $c$ for which two given complex numbers $a$ and $b$ are both preperiodic is finite iff $a^2 \neq b^2$. This is a dynamical analog of recent results of Masser and Zannier concerning simultaneous torsion sections on families of elliptic curves. This is joint work with Matt Baker. (Received September 21, 2009)

1056-37-1243 **Chinmaya Gupta*** (ccgupta@math.uh.edu), University of Houston, Department of Mathematics, 651PGH, 4800 Calhoun Rd, Houston, TX 77204, and **Mark Holland** and **Matthew Nicol**. *Extreme value theory for some dynamical systems.* Preliminary report.

Extreme value theory for dynamical systems concerns the limiting distribution of successive maxima or minima of the time-series arising from an observable on a dynamical system. For some dynamical systems it can be shown that the maximum of the time series behaves as if it was the maximum of an independent, identically distributed random sequence. We show that this is the case for some well-known examples of dynamical systems, such as hyperbolic billiards and Lozi-like maps. (Received September 21, 2009)

1056-37-1257 **Patrick R. LaVictoire*** (patlavic@math.berkeley.edu), UC Berkeley Department of Mathematics, 970 Evans Hall #3840, Berkeley, CA 94720. *Pointwise Divergence of $L^1$ Ergodic Averages Along the Nth Powers.*

Within the subject of ergodic subsequence averages $\frac{1}{N}\sum_{k=1}^{N} f(T^{a(k)}x)$, the question of pointwise convergence for $f \in L^1$ has turned out to be even more intricate than questions of norm convergence or even pointwise convergence for $L^2$ functions. As shown by Buczolich and Mauldin for the sequence of squares, a concentration of the sequence in residue classes can thwart an $L^1$ maximal inequality and the corresponding ergodic theorem. In this talk, we will explain the construction behind this result and generalize it to encompass sequences like the nth powers and the primes. (Received September 21, 2009)

1056-37-1393 **Wen-Xiu Ma*** (mawx@cas.usf.edu), Department of Mathematics and Statistics, University of South Florida, 4202 E Fowler Avenue, Tampa, FL 33620-5700.
*Component-trace identities and Hamiltonian structures of integrable couplings.*

Component-trace identities associated with matrix spectral problems will be presented and shown to be fundamental tools in establishing Hamiltonian structures of integrable couplings associated with non-semisimple Lie algebras. Applications of bi-trace identities will furnish Hamiltonian structures of dark equations including the first-order perturbation equations. (Received September 21, 2009)

1056-37-1460 **Paul von Dohlen*** (vondohlenp@wpunj.edu) and **Patrick Miller**. *Evolving a Smooth Curve of Initial Conditions Under a Time-Dependent Two-Dimensional ODE.*

For a system of nonlinear ODEs we evolve a smooth curve of initial conditions under successive iterations of the flow map. A $C^1$ Hermite interpolant represents the curve at each time slice with the requisite derivative information carried forward using the linear variational equation. In this setting, the goal is to use error estimates for the interpolating polynomial to determine where additional knots need to be inserted and carried forward under the flow, as well as determining where knots might be removed when parts of the curve become over-resolved. In this presentation we assume that the representation of the curve is accurate and illustrate how the interpolating knots can be positioned more efficiently by solving a certain ODE associated with reparametrizing the curve. (Received September 21, 2009)

1056-37-1508 **David E. Molnar***, 30 Ridge Rd #15, Ridgewood, NJ 07450. *Diophantine Approximation for Alternate Forms of Continued Fractions.*

The strength of a rational approximation $p/q$ to an irrational $x$ can be measured by the *approximation coefficient*, $\theta(x, \frac{p}{q}) = q^2|x - \frac{p}{q}|$. When $p/q$ is a convergent of the classical continued fraction expansion of $x$, $\theta(x, \frac{p}{q})$ is less than 1. A partial converse due to Legendre states that if $\theta(x, \frac{p}{q}) < 1/2$, then $p/q$ is a convergent to $x$. Another classical result due to Vahlen states that of any two consecutive convergents to an irrational $x$, at least one must have approximation coefficient less than $1/2$. We look at results like these for a family of continued fraction expansions generalizing the classical theory. (Received September 22, 2009)

1056-37-1685 **Julia A Barnes*** (jbarnes@email.wcu.edu), **Clinton Curry** and **Beth Schaubroeck**.
*Julia Sets and Graphing Iterates of Quadratic Polynomials.* Preliminary report.

Julia sets for the family of complex functions $f_c(z) = z^2 + c$ have been well-studied for years, and many people are familiar with the images of these Julia sets. However, the graphs of the functions $f_c(z)$ themselves and their iterates are more difficult to visualize because they are four-dimensional. In this talk, we explore the graphs of these functions by analyzing the graphs of the real and imaginary parts of the iterates of $f_c(z)$. Then we look at the limit of these projections and explore the connections between these graphs and the filled Julia sets of the corresponding functions. (Received September 22, 2009)

1056-37-1686 **Faina Berezovskaya*** (fberezovskaya@howard.edu), 6-th str., Washington, DC 20059, and **Artem Novozhilov** and **Georgy Karev**. *Newton diagram methods for analysis of the replicator equation.*

The replicator equation is at heart of many areas of mathematical biology. For each replicator equation the corresponding selection system can be considered for which effective methods of analysis were recently suggested [Karev,2009]. The original problem is reduced to the analysis of asymptotic behavior of the solutions of the so-called escort system, which in some important cases can be of smaller dimension than the original one.We apply the method of the Newton diagram [Berezovskaya,1979] to study the asymptotic behavior of the solutions of the escort system, when matrix A has rank 1 or 2. We analyze an arbitrary replicator equation with the matrix of rank 1 and, in particular, provide the conditions when the asymptotic state is an inner equilibrium. As an example of the system with rank 2 we consider the problem from [Adams & Sornborger,2007], for which we show, for arbitrary dimension of the system and under some suitable conditions, that generically one globally stable equilibrium exits on the 1-skeleton of the simplex. (Received September 22, 2009)

1056-37-1737 **Laura DeMarco*** (demarco@math.uic.edu), Department of Mathematics, University of Illinois at Chicago, 851 S Morgan St (M/C 249), Chicago, IL 60607. *The conformal geometry of billiards.*

A billiard trajectory on a rectangular table obeys a simple rule: it is either periodic or it covers the table uniformly, exactly as for straight lines on a torus. The study of billiard trajectories on other polygonal tables has led to striking connections with the conformal geometry of Riemann surfaces, the Teichmüller geometry of moduli space, and arithmetic properties of associated dynamical systems. I will explain some recent results in these directions. (Received September 22, 2009)

1056-37-1847 **Andrey Babichev*** (ababichev@wesleyan.edu), Department of Mathematics, 5245 North Backer Avenue M/S PB108, Fresno, CA 93740-8001, and **Adam Fieldsteel** (afieldsteel@wesleyan.edu). *Speedups of Ergodic Group Extensions.*

Let $T : X \to X$ be an invertible measure preserving transformation of the standard Lebesgue space $X$ (segment [0,1] with the standard measure), and let $k : X \to \mathbb{N}$ be a measurable function such that the variable power $T^k$ : $x \mapsto T^{k(x)}(x)$ is an invertible transformation as well. Then we say that $T^k$ is a *speedup* of $T$. In simpler terms, under a speedup points jump forward along their orbits, splitting them into suborbits. If $S : X \times G \to X \times G$ is an ergodic extension of $T$ by rotations of a compact group $G$ (so $S : (x, g) \mapsto (T(x), \sigma(x)g)$ for some skewing function $\sigma : X \to G$) and $k$ is as above, we say that $S_1^k : (x, g) \mapsto S_1^{k(x)}(x, g)$ is a *factor speedup* of $S$.

Let now $S_1$ and $S_2$ be ergodic extentions of finite measure preserving transformations $T_1$ and $T_2$ by rotations of a compact group $G$. We prove that there is a factor speedup of $S_1$ that is isomorphic to $S_2$ by an isomorphism that respects the action of $G$ on fibers. In the case $G = \{e\}$ this recovers the theorem of Arnoux, Ornstein and Weiss that given any two ergodic measure preserving transformations, there is a speedup of the first that is isomorphic to the second. (Received September 22, 2009)

1056-37-1929 **Jonathan C Mattingly*** (jonm@math.duke.edu), Department of Matthematics, Physics Building, Duke University, durham, NC 27708. *Long Time Behavior of Stochastically Forced PDEs.*

I will discuss the ergodic behavior of stochastically forced partial differential equations. I will touch on the question of what makes an SPDE elliptic verses hypo-elliptic and how this is reflected in their qualitative behavior. I will use a number of example of physical and modeling interest to illustrate my discussion. Including the 2D Navier- Stokes equations and reaction diffusion equations. (Received September 22, 2009)

1056-37-1942 **Ross M Ptacek*** (rptacek@uab.edu), 3419-B Primm Lane, Hoover, AL 35216, and **John C Mayer**. *Combinatorial Classification of Cubic Polynomials with a fixed Siegel Disk.* Preliminary report.

We will consider the dynamics of polynomial maps of the form $z \mapsto \lambda z + a_1 z^2 + a_2 z^3$ where the phase of $\lambda$ is an irrational of Brjuno type. In this case, the map is linearizable in a neighborhood of 0, and the maximal such neighborhood is called a Siegel Disk. One of the critical points of the map always accumulates on the boundary of the Siegel Disk. We adopt Zakeri's paramerterization and corresponding connectedness locus, $\mathcal{M}(\theta)$. The components of the interior of $\mathcal{M}(\theta)$ are classified by how the critical point not necessarily associated with the Siegel disk behaves. In particular we consider *capture* components, in which the this critical point eventually maps into the Siegel Disk. Let $\mathcal{C}$ be the union of the closures of all capture components. We define the Principal Capture Locus to be the component of $\mathcal{C}$ whose closure contains 1. We first define internal addresses for $\mathcal{C}$ and then use Thurston laminations to classify the dynamics of maps represented in $\mathcal{C}$. Finally, we extend the laminational model to points in the closure of the Principal Capture Locus where the corresponding Julia set exhibits two distinct quadratic behaviors rather than a single cubic behavior. (Received September 22, 2009)

1056-37-1994 **Constantine Georgakis*** (cgeorgak@condor.depaul.edu), Department of Mathematics, DePaul University, 2320 N.Kenmore Avenue, Chicago, IL 60614-3250. *The Maximal Inequality and the Ergodic Theorem for Discrete Hausdorff Means.* Preliminary report.

The classical maximal inequality and the ergodic theorem for the space Lp was extended to the class of Cesaro means of order a of the iterates of a measure preserving transformation on a probability space by R.Irmisch and Y.Deriennic under the condition that ap>1 and for a between 0 and 1. It is shown that the result is valid for a wider class of discrete Hausdorf means which are generated by an absolutely continuous probability measure on the unit interval whose density satisfies an integrability condition that reduces to that of the Cesaro means of order a when the probability measure is a Beta density with parameters(1,a). (Received September 22, 2009)

1056-37-2021 **Sasa Kocic*** (s.kocic@utoronto.ca), Department of Mathematics, University of Toronto, 40 St. George Street, Toronto, ON M5S 2E4, Canada, and **Hans Koch** (koch@math.utexas.edu), 1 University Station, C1200, Austin, TX 78712. *Renormalization and lower-dimensional Brjuno invariant tori of Hamiltonian systems.*

KAM theory establishes the persistence of invariant tori with Diophantine frequency vectors under small perturbations of integrable Hamiltonian systems. In this talk, we will discuss a renormalization approach to the problem. We construct a renormalization scheme and apply it to prove the existence of lower-dimensional invariant tori (tori of dimension $d$, lower than the number of degrees of freedom $d + D$) with Brjuno frequency vectors in near-integrable Hamiltonian flows. For every Brjuno frequency vector $\omega \in \mathbb{R}^d$ and every vector $\Omega \in \mathbb{R}^D$ satisfying an arithmetic condition with respect to $\omega$, there exists an analytic manifold $\mathcal{W}$ of infinitely renormalizable

Hamiltonian vector fields; each vector field on $\mathcal{W}$ is shown to have an analytic invariant torus with frequency vector $\omega$. (Received September 22, 2009)

# 39 ► Difference and functional equations

1056-39-28 **Jeffrey W Lyons*** (Jeff_Lyons@baylor.edu), 1226 James Ave Apt 210, Waco, TX 76706. *Boundary Data Smoothness for Solutions of Nonlocal Boundary Value Problems for nth Order Difference Equations.* Preliminary report.

Under certain conditions, derivatives and differences, with respect to boundary data and parameters, are studied for solutions of the $n$th order discrete nonlocal boundary value problem, $w(m+n) = f(m, w(m), w(m+1), \dots, w(m+n-1))$, $w(m_i) = w_i$, for $1 \le i \le n-1$, and $w(m_n) - \sum_{i=1}^{r} \alpha_i w(\eta_i) = w_n$, where $m_1 < m_1+1 < m_2 < m_2+1 < \cdots < m_{n-1} < m_{n-1}+1 < \eta_1 < \eta_1+1 < \eta_2 < \eta_2+1 < \cdots < \eta_r < \eta_r+1 < m_n$ in $\mathbb{Z}$ and $\alpha_1, \alpha_2, \dots, \alpha_r \in \mathbb{R}$. (Received June 10, 2009)

1056-39-34 **Mostafa Ghandehari*** (ghandeha@uta.edu), BNuiv. of Texas at Arlington, Civil Engineering, Box 19308, Arlington, TX 76019, and **Shahrzad Sheibani**. *The Z-transform of queuing systems.* Preliminary report.

The Z-transform is used to analyze the differential-difference equation for a queuing system. After taking the Z-transform a linear first order ordinary differential equation is obtained. The solution of the differential equation will give transform of transitional probabilities. The inverse Z-transform will give analytic expressions for transitional probabilities. An application in CPU scheduling is discussed. (Received July 06, 2009)

1056-39-118 **Raegan Higgins*** (raegan.higgins@ttu.edu), Department of Mathematics & Statistics, Lubbock, TX 79402-1042. *Oscillation Criteria for Second Order Linear Delay Dynamic Equations.* Preliminary report.

In this talk we consider the second-order linear delay dynamic equation

$$\left(p(t)y^{\Delta}(t)\right)^{\Delta} + q(t)y(\tau(t)) = 0$$

on a time scale $\mathbb{T}$. By employing the Riccati transformation technique, we establish some sufficient conditions which ensure that every solution oscillates. The obtained results unify the oscillation of second-order delay differential and difference equations. We illustrate our results with examples. (Received September 22, 2009)

1056-39-232 **Timothy Sauer*** (tsauer@gmu.edu), Department of Mathematics, George Mason University, Fairfax, VA 22030. *Global convergence of max-type equations.*

Consider a multivariable difference equation whose evolution rule is defined as the maximum of several difference equations in one variable. It is shown that if the individual equations are each contractive, then the aggregated max-type equation converges to a fixed point. A corresponding result holds for local convergence. Similar results hold for generalizations of these equations, called k-rank equations. (Received August 17, 2009)

1056-39-320 **Gerasimos E Ladas*** (gladas@math.uri.edu), University of Rhode Island, Department of Mathematics, Lippitt Hall, Kingston, RI 02881-0816. *Open Problems and Conjectures in Difference Equations.* Preliminary report.

We present some open problems and conjectures about some interesting types of difference equations. We are primarily interested in the boundedness nature of solutions, the periodic character of the equation, the global stability behavior of the equilibrium points, and with convergence to periodic solutions including periodic trichotomies. (Received August 28, 2009)

1056-39-347 **Lih-Ing W Roeger*** (lih-ing.roeger@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Box 41042, Lubbock, TX 79409-1042. *Dynamically consistent discrete-time Lotka-Volterra models.* Preliminary report.

Discrete-time difference equation systems are derived from Lotka-Volterra differential equation systems using nonstandard finite difference schemes. The difference equations are dynamically consistent with their continuous counterparts. The positivity of solutions, monotonicity of solutions, and local stability of equilibria are all preserved. We generalize Liu and Elaydi's discrete-time Lotka-Volterra competition model [Journal of Computational Analysis and Applications, **3**: 53–73, 2001]. (Received September 01, 2009)

1056-39-372 **Allan Peterson*** (apeterson1@math.unl.edu), 6650 Blue Ridge Lane, Lincoln, NE 68516, and **Lynn Erbe**. *Qualitative Behaviour of Dynamic Equations on Time Scales.* Preliminary report.

We will be concerned with the asymptotic behaviour of solutions of certain dynamic equations on time scales. Many examples will be given. (Received September 02, 2009)

1056-39-390 **Qingkai Kong** and **Min Wang*** (mwang@math.niu.edu), Department of Mathematical Sciences, Northern Illinois University, DeKalb, IL 60115. *Positive solutions of even order periodic boundary value problems.*

We study a class of periodic boundary value problems associated with even order differential equations. By applying the Krasnosel'skii fixed point theorem and the fixed point index theory, we establish a series of criteria for the problem to have one, two, arbitrary number, and even an infinite number of positive solutions. Criteria for the nonexistence of positive solutions are also derived. These criteria are given by explicit conditions which are easy to verify. Several examples are provided to show the applications. Our results extend, improve, and supplement many results in the literature, even for the second order case. (Received September 21, 2009)

1056-39-398 **Adam B Baharum** (adam@cs.usm.my), School of Mathematical Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia, **AlQahtani Hessah*** (hussahq@hotmail.com), School of Mathematical Sciences, Universiti Sains Malaysia, Penang, 11800, Saudi Arabia, **Zalila B Ali** (zalila@cs.usm.my), School of Mathematical Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia, **Habibah B Latih** (habibah@usm.my), School of Mathematical Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia, and **Swee Peng Koay**, School of Mathematical Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia. *Modeling of Groundwater Level of a Specified Cut Slope.*

In active landslide, the prediction of acceleration of movement is crucial issue for the design and performance of warning systems. Landslide occurs when a sudden increase beyond the critical level of groundwater. This is especially true in tropical weather during the wet season. The purpose of this study is to use numerical model to simulate groundwater flow. The goal of this modeling is to predict the value of unknown nodal points in the groundwater piezometric head. The numerical technique used is the finite difference method. The finite difference method one of the oldest, most general applicable and most easily understood methods of obtaining numerical solution to steady and unsteady groundwater problems. After we obtain the algebraic approximation equations for each node in solution boundary domain, we solve them with digital computer program. Our research presents a broad, comprehensive overview of the fundamental concepts and applications of computerized groundwater modeling. The research covers finite difference method and includes simulation runs to demonstrate theoretical points described. Our model is able to predict the value of aquifer parameters in particular slope. (Received September 04, 2009)

1056-39-439 **Lynn H Erbe*** (lerbe2@math.unl.edu), Department of Mathematics, Univesity of Nebraska, Lincoln, NE 68588, and **Allan C. Peterson** and **Baoguo Jia**. *Oscillation and nonoscillation for nonlinear dynamic equations.*

We present some recent results for oscillation and nonoscillation of second order Emden-Fowler dynamic equations on time scales. In particular, we consider the sublinear case and give sufficient conditions for oscillation and for nonoscillation and relate these to some earlier results obtained for the difference equations case. (Received September 07, 2009)

1056-39-505 **Chris Ahrendt*** (s-cahrend1@math.unl.edu), University of Nebraska-Lincoln, 203 Avery Hall - Dept. of Mathematics, P.O. Box 880130, Lincoln, NE 68588-0130. *Some Properties of the Generalized Laplace Transform on Time Scales.*

We first discuss several properties of the generalized exponential function which will allow us to explore some of the fundamental properties of the Laplace transform on time scales. We then give a description of the region in the complex plane for which the improper integral in the definition of the Laplace transform converges, and how this region is affected by the time scale in question. Conditions under which the Laplace transform of a power series can be computed term-by-term are given. Regressivity and its relationship to the Laplace transform is examined. (Received September 10, 2009)

1056-39-746 **Abdulkadir Dogan** and **John R Graef*** (John-Graef@utc.edu), Department of Mathematics, The University of Tennessee at Chattanooga, Chattanooga, TN 37403, and **Lingju Kong**. *Higher order singular multi-point boundary value problems on time scales.*

We study the singular boundary value problem

$$\left(\phi\left(u^{\Delta^{n-1}}\right)\right)^{\nabla} + \lambda a(t) f(u) = 0,\ t \in (0,T)_{\mathbb{T}},$$

$$\begin{cases} u^{\Delta^i}(0) = \sum_{j=1}^m \alpha_j u^{\Delta^i}(\xi_j),\ i = 0,\dots,n-2, \\ \phi\left(u^{\Delta^{n-1}}(T)\right) = \sum_{j=1}^m \beta_j \phi\left(u^{\Delta^{n-1}}(\xi_j)\right), \end{cases}$$

on a time scale $\mathbb{T}$. Conditions for the existence and uniqueness of positive solutions are obtained. The dependence of positive solutions on the parameter $\lambda$ is studied. We also present similar results for a problem with the same differential equation and different boundary conditions. The results are illustrated with examples. Our analysis mainly relies on the mixed monotone operator theory. (Received September 16, 2009)

1056-39-764 **Sukanya Basu*** (sukanya.basu@mwsu.edu), Mathematics Department, Midwestern State University, 3410 Taft Blvd., Wichita Falls, TX 76308. *Global Behavior of Solutions to a Planar System of First-Order Rational Difference Equations.*

For positive parameters $\alpha_1$, $\beta_1$, $\gamma_1$, $A_1$, $B_1$, $C_1$, $\alpha_2$, $\beta_2$, $\gamma_2$, $A_2$, $B_2$ and $C_2$, consider the system of first-order rational difference equations

$$\left.\begin{aligned} x_{n+1} &= \frac{\alpha_1 + \beta_1 x_n + \gamma_1 y_n}{A_1 + B_1 x_n + C_1 y_n} \\ y_{n+1} &= \frac{\alpha_2 + \beta_2 x_n + \gamma_2 y_n}{A_2 + B_2 x_n + C_2 y_n} \end{aligned}\right\}, \quad n = 0,1,2,\dots \tag{E}$$

I will discuss the global behavior of all solutions to system (E) whose initial conditions are non-negative. (Received September 16, 2009)

1056-39-771 **Vadim Tkachenko*** (tkachenk@math.bgu.ac.il), Department of Mathematics, Ben-Gurion University of the Negev, P.O.B.653, 84105 Beer-Sheva, Israel. *Differential-difference Equations in Entire Functions.*

For a linear differential-difference equation

$$\sum_{k=0}^{m} \sum_{j=0}^{p_k} a_{jk}(z) \phi^{(j)}(z + \alpha_k) = \gamma(z)$$

with real shifts in the complex plane we prove a theorem of existence of entire solutions for an arbitrary entire function in the r.h.s. and, using it, show that the space of entire solutions of the corresponding homogeneous equation is infinite dimensional. This is the joint talk with G.Belitskii. (Received September 17, 2009)

1056-39-916 **April Harry** (aharry@xula.edu), Department of Mathematics, Xavier University of Louisiana, PO box 62, New Orleans, LA 70125, **Candace M Kent** (CMKENT@VCU.EDU), Mathematics and Appl. Mathematics Department, Virginia Commonwelth University, PO Box 842014, Richmond, VA 23284, and **Vlajko L Kocic*** (vkocic@xula.edu), Department of Mathematics, Xavier University of Louisiana, Po Box 62, New Orleans, LA 70125. *The Dynamics of the Periodically Forced Sigmoid Beverton-Holt Model, part I.* Preliminary report.

We study the dynamics of periodically forced Sigmoid Beverton-Holt model

$$x_{n+1} = \frac{a_n x_n^{\delta}}{1 + x_n^{\delta}}, n = 0, 1, ...$$

where $\{a_n\}$ is positive p-periodic sequence, $\delta > 0$, and initial condition $x_0 > 0$.

In the case when $\delta = 1$, the ab ove equation reduces to well-known periodically forced Beverton-Holt model which has been thoroughly studied recently. The autonomous case of the above equation ($a_n = a = const$) was introduced and widely used in fisheries science as a model which exibits the Allee effect.

In this paper we study the extreme stability, the existence of periodic solutions and their stability, Allee effect, and attenuance of periodic cycles. (Received September 18, 2009)

1056-39-917 **April Harry** (aharry@xula.edu), Department of Mathematics, Xavier University of Louisiana, PO box 62, New Orleans, LA 70125, **Candace M Kent*** (CMKENT@VCU.EDU), Virginia Commonwealth University, Mathematics and Appl. Mathematics Department, PO Box 842014, Richmond, VA 23284, and **Vlajko L Kocic** (vkocic@xula.edu), Department of Mathematics, Xavier University of Louisiana, Po Box 62, New Orleans, LA 70125. *The Dynamics of the Periodically Forced Sigmoid Beverton-Holt Model, part II.* Preliminary report.

This is a continuation of study of the dynamics of periodically forced Sigmoid Beverton-Holt model

$$x_{n+1} = \frac{a_n x_n^\delta}{1 + x_n^\delta}, n = 0, 1, ...$$

where $\{a_n\}$ is positive p-periodic sequence, $\delta > 0$, and initial condition $x_0 > 0$. (Received September 18, 2009)

1056-39-1017 **N Saber Elaydi*** (selaydi@trinity.edu), one trinity place, San Antonio, TX 78216. *Competition Models with Allee effects.* Preliminary report.

We propose new discrete competition models with Allee effects. The talk will present results on stability and bifurcation of fixed and periodic orbits. It will include both theoretical and numerical methods. One of the effective tools in our study is the the construction of associated skew-product discrete dynamical systems. Finally, the question of whether periodic forcing will result in the attenuance (deleterious effect) or resonance (beneficial) in competition models, will be addressed. (Received September 20, 2009)

1056-39-1070 **Harold M Hastings*** (harold.hastings@hofstra.edu), Dept. of Physics and Astronomy, Berliner 102, 151 Hofstra University, Hempstead, NY 11549-1510, and **Michael Bantegui**, **Michael Palmer** and **Thomas Savino**. *Stability and complexity of small random systems of stochastic linear difference equations.*

We explore the stability of the small random systems of stochastic linear difference equations, typically involving 10-20 variables, motivated by dynamics of the world trade network and the US and Canadian power grid. Partially supported by the Department of Energy Award DE-FG02-08ER64623. This report was prepared as an account of work sponsored by an agency of the US Government. Neither the US Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the US Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the US Government or any agency thereof. (Received September 20, 2009)

1056-39-1290 **E. A. Grove** and **Y. Kostorv*** (ykostrov@xula.edu), 4859 West Napoleon ave, Apt # 204, metairie, LA 70001, and **M. Radin** and **S. Schultz**. *On The Global Behavior Of A System Of Rational Difference Equations.* Preliminary report.

We show that the system of rational difference equations

$$x_{n+1} = \frac{\alpha_1}{x_n + y_n} \qquad , \qquad y_{n+1} = \frac{\alpha_2 + y_n}{B_2 x_n + y_n}$$

is permanent, where the initial conditions $x_0, y_0 \in (0, \infty)$ and the parameters $\alpha_1, \alpha_2, B_2 \in (0, \infty)$ of the system are positive real numbers. We also find sufficient conditions for every positive solution of the system to converge. (Received September 21, 2009)

1056-39-1322 **Raegan Higgins*** (raegan.higgins@ttu.edu), Box 41042, Lubbock, TX 79423-1042. *A Model of an SIR Disease on Time Scales.* Preliminary report.

We formulate and analyze a model for an infectious disease on time scales. We derive a threshold value and show how this value is used to determine the likelihood of an epidemic. These results unify those obtained for differential and difference equations. (Received September 22, 2009)

1056-39-1470 **Mihai Stoiciu*** (mstoiciu@williams.edu), Williams College, Department of Mathematics and Statistics, Bronfman Science Center, Williamstown, MA 01267, and **Norbert Peyerimhoff**, Department of Mathematical Sciences, Durham University, UK. *Unitary Operators Associated to Hyperbolic Reflection Groups.* Preliminary report.

We consider singular continuous measures on the unit circle associated to groups of reflections in the hyperbolic disk. To each such measure we associate the family of orthogonal polynomials on the unit circle, the corresponding difference equation and the CMV operator, which is the unitary analog of the Jacobi operator. We describe the transition in the spectral properties of the CMV operator when the Hausdorff dimension of the support of the singular measure changes continuously from 0 to 1. (Received September 21, 2009)

1056-39-1491 **Nickolai Kosmatov*** (nxkosmatov@ualr.edu), University of Arkansas at Little Rock, 2801 S. University Ave., Little Rock, AR 72204. *A predator-prey system on a time scale.* Preliminary report.

We consider a predator-prey system on a time scale with impulsive effects and the Beddington-DeAngelis functional response and stage structure. We obtain solvability conditions using the coincidence degree theory. (Received September 22, 2009)

1056-39-1540 **Heidi A Berger*** (heidi.berger@simpson.edu), Simpson College, Department of Math, 701 N. C Street, Indianola, IA 50125. *The Existence of Multiple Nontrivial Solutions of Boundary Value Problems of Second-Order Dynamic Equations on a Time Scale.* Preliminary report.

I will use Clark's Theorem to show the existence of multiple solutions to a self-adjoint second-order dynamic boundary value problem that generalizes a Sturm-Liouville problem on a time scale. This work generalizes that done by Rabinowitz for PDEs in 1986 and work done by Bai and Xu for difference equations in 2007. Examples of the main results will be presented. (Received September 22, 2009)

1056-39-1846 **Youssef M Dib*** (dib@ulm.edu), 700 University Ave, Monroe, LA 71203, and **Mariette Maroun**, 700 University Ave, Monroe, LA 71203. *A difference equation model to measure the length of Latency of HSV1 infections in differential cells.*

A nonlinear difference equation model for HSV1 viral infections will be provided. Differential cell are the host of this virus. Once infected, this differential cell would survive as long as it host this virus. It is assumed that both HSV1's DNA and Nuclear DNA in the differential cell depend on Thyroid Hormone liganded with its receptore. Biological relevence of this model will be presented in addition to its' sensitivity study. Coexictense results between HSV1 virus and it's neuronal cell depend not only on parameter conditions but also on initial conditions. (Received September 22, 2009)

1056-39-1865 **Richard T Guy*** (guyrt7@wfu.edu), Department of Computer Science, Wake Forest University, Winston-Salem, NC 27109, **Kenneth S Berenhaut** (berenhks@wfu.edu), Department of Mathematics, Wake Forest University, Winston-Salem, NC 27105, and **Katherine M Donadio**, Department of Mathematics, Wake Forest University, Winston-Salem, NC 27105. *Applications of number theory to asymptotic behavior of solutions of difference equations.*

This talk focuses on asymptotic behavior of solutions of two families of equations. First, equations of the form

$$y_n = \min(f(y_{n-k_1}, y_{n-m_1}), \dots, f(y_{n-k_L}, y_{n-m_L}))$$

will be considered, with attention to conditions on $f$ and $\{k_i, m_i\}$ that guarantee asymptotically periodic solutions. We will also present recent work on a question related to equal representation of classes within periods. (Received September 22, 2009)

1056-39-1943 **Anton Dzhamay*** (adzham@unco.edu), 2250A Ross Hall, School of Mathematical Sciences, University of Northern Colorado, Greeley, CO 80639. *On the Lagrangian Description of Discrete Integrable Systems.* Preliminary report.

We consider Lax representations of discrete integrable systems whose space of Lax matrices is the space of $m \times m$ rational matrix functions. The discrete dynamics is given by the transformations of the form $\tilde{L}(z) = R(z)L(z)R(z)^{-1}$, where $R = R(L)$. This dynamic is symplectic with respect to a natural symplectic form, called the Krichever-Phong form. A nice feature of this form is that it can be written, in a very general setting, completely in terms of the Lax representation data. In this project, joint with I. Krichever, we study the Lagrangian description of such systems. (Received September 22, 2009)

1056-39-2059 **Tamara Eugenia Awerbuch-Friedlander*** (tamara@hsph.harvard.edu), 665 Huntington Ave, Boston, MA 02115, and **Richard Levins** (Humaneco@hsph.harvard.edu), 665 Huntington ave, Boston, MA 02445. *The Aging Heart and the Loss of Complexity- a Difference Equation Model.* Preliminary report.

There are indications that the heart-beat rate of humans looses variability as it ages. An initial examination of the time series data, obtained from ECG studies, shows that if we plot the RR interval (the time intervals between beats) as a function of beat number, the young healthy heart exhibits more variability than the old one. The dynamics observed in the rhythm of a young healthy heart is considered "chaotic" and typically reflects physiologic vitality. The transition from chaos to periodic oscillation as in the aging heart, indicates a compromise of cardiac function. Models based on difference equations to explain ECG data of young and old individuals are being constructed. The equations will display changes in dynamical patterns based on parameter values. First we characterize the system looking at the relationship of each beat to previous beats. This is done through statistical analysis in order to produce a phase space map to be used to explore the possibility of a mechanism that can be described by a non-linear difference equation or by a set of non-linear difference equations. Our preliminary results show a loss of non-linearity as the heart ages, indicating some loss of physiological control. (Received September 23, 2009)

# 40 ► *Sequences, series, summability*

1056-40-1660 **Robert Molina** and **Aklilu Zeleke*** (zeleke@msu.edu), E-194A Holmes Hall, Lyman Briggs College and, Department of Statistics & Probability, East Lansing, MI 48825. *On the Convergence of Maximum Roots of a Fibonacci Type Polynomial Sequence.*

For a positive integer $k$, consider a Fibonacci type polynomial sequence given by $G_0(x) = -1, G_1(x) = x - 1$ and $G_n^k(x) = x^k G_{n-1}(x) + G_{n-2}(x)$, $n \geq 2$. Let $g_n^k$ be the maximum root of $G_n^k$ and $\alpha_k$ be the (maximum)root of $P_k(x) = x^k - x^{k-1} + x - 2$. We will show that $g_{2n}^k$ converges monotonically to $\alpha_k$ from above and $g_{2n+1}^k$ converges monotonically to $\alpha_k$ from below. (Received September 22, 2009)

# 41 ► *Approximations and expansions*

1056-41-37 **George A Anastassiou*** (ganastss@memphis.edu), DEPARTMENT OF MATHEMATICAL SCIENCES, University of Memphis, Memphis, TN 38152, and **Razvan A Mezei** (rmezei@memphis.edu), Department of Mathematical Sciences, University of Memphis, Memphis, TN 38152. *Lp Convergence with Rates of Smooth Poisson-Cauchy Type Singular Operators.*

In this talk we present the study of smooth Poisson-Cauchy Type singular integral operators on the line regarding their convergence to the unit operator with rates in the Lp norm, p is greater equal one. The related established inequalities involve the higher order Lp modulus of smoothness of the engaged function or its higher order derivative. (Received July 07, 2009)

1056-41-331 **Vladimir Temlyakov** and **Mingrui Yang*** (yangm@mailbox.sc.edu), Department of Mathematics, LeConte College, 1523 Greene Street, University of South Carolina, Columbia, SC 29208, and **Peixin Ye**. *Greedy Approximation with regard to Non-greedy Bases.*

The main goal of this paper is to understand which properties of a basis are important for certain direct and inverse theorems in nonlinear approximation. We study greedy approximation with regard to bases with different properties. We consider bases that are tensor products of univariate greedy bases. Some results known for unconditional bases are extended to the case of quasi-greedy bases. (Received August 29, 2009)

1056-41-426 **Qin Wu*** (qinwu@math.wvu.edu), 810 College Ave Apt A, Morgantown, WV 26505, and **Sherman Riemenschneider**. *Ratio Boundary Extension for Empirical Mode Decomposition.*

A new idea about the boundary extension has been introduced and applied to the Empirical Mode Decomposition (EMD) algorithm. Instead of the traditional mirror extension on the boundary, we propose a ratio extension on the boundary. The stop criteria for B-Spline based EMD algorithm is also discussed. Numerical experiments are used for empirically assessing performance of the modified EMD algorithm. The examples indicate that the ratio boundary extension indeed improves the result of the original EMD. (Received September 18, 2009)

1056-41-679 **Julia Petereit*** (jpetereit@unr.edu), University of Nevada, Reno, 1664 N. Virginia St., MS 084, Reno, NV 89557. *Decomposition Method for Henry's Problem.*

Henry's problem is a classic problem in groundwater hydrology. It models the interaction between saltwater and freshwater in confined reservoirs adjacent to the ocean shore.

The traditional semi-analytical solution by Henry to the problem is based on the Fourier-Galerkin technique, which is not very accurate. This causes a difficulty because we are in need of a more accurate analytical solution since currently the Henry's problem is often used to check the validity of numerical codes for variable density flow and transport.

In this presentation we propose an approximate analytical solution to Henry's problem based on a decomposition method. (Received September 15, 2009)

1056-41-729 **Mohammed A. Qazi*** (qazima@aol.com), Dept. of Mathematics, Tuskegee University, Tuskegee, AL 36088, and **Q. I. Rahman**, Dépt. de Mathématiques et de Statisque, Université de Montréal, Montréal, Québec H3C 3J7, Canada. *Extensions of Bernstein's Inequality to Rational Functions.*

Let $\mathcal{P}_n$ be the class of all polynomials of degree at most $n$. It is known that if $f \in \mathcal{P}_n$ and $|f(z)| \le 1$ on the unit circle, then $|f'(z)| \le n\,|z|^{n-1}$ outside the unit disk. We present an 'extension' of this result to rational functions having all their poles in the open unit disk. (Received September 16, 2009)

1056-41-770 **Zuowei Shen*** (matzuows@nus.edu.sg), Department of Mathematics, National University of Singapore, Singapore, Singapore. *Dual Gramian Analysis and its development.*

This talk is to give a short survery on Dual Gramian analysis, its application and development. In particular, the unitary extension principle and duality principle via the Gramian analysis will be discussed. (Received September 17, 2009)

1056-41-812 **Jeremy Wade*** (jwade@pittstate.edu), Department of Mathematics, Pittsburg State University, 1701 S. Broadway, Pittsburg, KS 66762. *Cesáro Summability of Expansions in Orthogonal Polynomials on a Cylinder.*

We investigate Cesàro summability of the Fourier orthogonal expansion of functions on $B^d \times I^m$, where $B^d$ is the closed unit ball in $\mathbb{R}^d$ and $I^m$ is the $m$-fold Cartesian product of the interval $[-1, 1]$, in terms of orthogonal polynomials with respect to the weight functions $(1-z)^{\alpha}(1+z)^{\beta}(1-|x|^2)^{\lambda-1/2}$, with $z \in I^m$ and $x \in B^d$. Using generating functions, we are able to obtain convergence of the $(C, \delta)$-means for suitably large values of $\delta$. (Received September 17, 2009)

1056-41-852 **Robert Calderbank*** (calderbk@math.princeton.edu), Department Of Mathematics, Princeton University, Princeton, NJ 08544, **Stephen D Howard** (Stephen.Howard@dsto.defence.gov.au), P.O. Box 1500, Edinburgh, 5111, Australia, and **Sina Jafarpour** (sina@cs.princeton.edu), Department of Computer Science, Princeton University, Princeton, NJ 08544. *Construction of a Large Class of Deterministic Sensing Matrices that Satisfy a Statistical Isometry Property.*

In the standard Compressed Sensing paradigm, the $N \times \mathcal{C}$ measurement matrix $\Phi$ is required to act as a near isometry on the set of all $k$-sparse signals (Restricted Isometry Property or RIP). If $\Phi$ satisfies the RIP, then Basis Pursuit or Matching Pursuit recovery algorithms can be used to recover any $k$-sparse vector $\alpha$ from the $m$ measurements $\Phi\alpha$. Although it is known that certain probabilistic processes generate $N \times \mathcal{C}$ matrices that satisfy RIP with high probability, there is no practical algorithm for verifying whether a given sensing matrix $\Phi$ has this property. In contrast we provide simple criteria that guarantee that a deterministic sensing matrix acts as a near isometry on an overwhelming majority of $k$-sparse signals; in particular, most such signals have a unique representation in themeasurement domain. An essential element in our construction is that we require the columns of the sensing matrix to form a group under pointwise multiplication. The construction allows recovery methods for which the expected performance is sub-linear in $\mathcal{C}$, and only quadratic in $N$, as compared to the super-linear complexity in $\mathcal{C}$ of the Basis Pursuit or Matching Pursuit algorithms. (Received September 18, 2009)

1056-41-906 **Kasso A Okoudjou*** (kasso@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *Gabor frames and Strichartz estimates.* Preliminary report.

We use the characterization of functions in the modulation spaces by means of Gabor frames to prove new Strichartz estimates for the Schrödinger equation on these spaces. As a consequence of our results, we obtain establish some local wellposdeness for nonlinear Schrödinger equations with initial data in the modulation spaces. (Received September 18, 2009)

1056-41-926 **Charles Micchelli**, **Yuesheng Xu** and **Haizhang Zhang*** (haizhang@umich.edu), Ann Arbor, MI 48109. *Optimal Learning of Bandlimited Functions from Localized Sampling.*

Motivated by the celebrated Shannon sampling theorem, we consider the recovery of a bandlimited function from its localized sampling. The intrinsic approximation error is formulated. In the univariate case, we obtain its upper bound and lower bound estimates, which indicate that the approximation error decays exponentially (but not faster) to zero. A practical algorithm which satisfies the upper bound estimate is provided. Multivariate results are also established. (Received September 18, 2009)

1056-41-962 **Joseph Kolibal*** (Joseph.Kolibal@usm.edu), Department of Mathematics, 118 College Drive 5045, Hattiesburg, MS 39406-0001. *The second derivatives of the Chebyshev polynomials as $M$-matrices.* Preliminary report.

We develop a matrix formalism for expressing the second order derivative of the Chebyshev polynomials in a Chebyshev basis, allowing for the implementation of a direct methods for computing particular solutions for some inhomogeneous elliptic PDEs. The resulting matrix is an $M$-matrix whose coefficents can be explicitly generated with ease for computational studies. (Received September 19, 2009)

1056-41-1114 **Rong-Qing Jia*** (rjia@ualberta.ca), Department of Mathematical Sciences, Unniversity of Alberta, CAB 632, Edmonton, Alberta T6G 2G1, Canada. *Spectral Properties of the Transition Operators Associated with Box Splines.* Preliminary report.

We investigate Riesz bases generated from box splines. This investigation leads us to a study of refinement equations with masks being exponentially decaying sequences. Various properties of Riesz bases and their dual bases can be characterized by the spectral properties of the transition operators associated with the refinement masks. It turns out that the transition operator associated with an exponentially decaying mask is a compact operator on a certain Banach space of sequences. Moreover, an order structure can be introduced so that the relevant transition operator is a positive operator. Furthermore, when the refinement mask is induced by box splines, by using the algebraic properties of box splines, we demonstrate that the transition operator is strongly positive in many cases of interest to applications. By invoking the theory of compact positive operators we design efficient algorithms to calculate desirable eigenvalues of the transition operator. The theory and numerical computation developed in our work will be important for the study of Riesz bases and their dual bases associated with box splines. (Received September 21, 2009)

1056-41-1310 **Mohammad A AlQudah*** (alqud1ma@cmich.edu), Department of Mathematics, Mount Pleasant, MI 48859, and **James R Angelos** (james.angelos@cmich.edu), Department of Mathematics, Mount Pleasant, MI 48859. *Local Lipschitz Constant for Vector Valued Approximation.* Preliminary report.

Let $X$ be a compact Hausdorff space and $C(X, \mathbb{R}^k)$ be the space of vector valued continuous functions from $X$ to $k-$dimensional Euclidean space $\mathbb{R}^k$.

The best approximation in $C(X, \mathbb{R}^k)$ for $k \geq 2$ is fundamentally different from the best approximation in $C(X, \mathbb{R})$ where Lipschitz continuity of order one and strong uniqueness of order one are essentially equivalent.

We present a formula for the local Lipschitz constant for uniform approximation of $f$ on a discrete subset $X$ of $[-1, 1]$ from a generalized Haar subspace of dimension $n$ in $C(X, \mathbb{R}^k)$, under the restriction that $X$ has exactly $n+1$ points. (Received September 21, 2009)

1056-41-1525 **Lawrence Carin*** (lcarin@ece.duke.edu), Electrical & Computer Engineering Department, Box 90291, Durham, NC 27708-0291. *Nonparametric Manifold Learning and Compressive Sensing.*

Nonparametric Bayesian methods are employed to constitute a mixture of low-rank Gaussians, for data that are of high dimension N but are constrained to reside in a low-dimensional subregion of $\mathbb{R}^N$. The number of mixture components and their rank are inferred automatically from the data. The resulting algorithm can be used for learning manifolds and for reconstructing signals from manifolds, based on compressive sensing (CS) projection measurements. The statistical CS inversion is performed analytically. We derive the required number of CS random measurements needed for successful reconstruction, based on easily computed quantities, drawing on block–sparsity properties. The proposed methodology is validated on several synthetic and real datasets. (Received September 22, 2009)

1056-41-1726 **Laura Angeloni*** (angeloni@dipmat.unipg.it), Dipartimento di Matematica e Informatica, Universita' degli Studi di Perugia, Via Vanvitelli 1, 06123 Perugia, Italy. *Convergence and Rate of Approximation for Generalized Sampling-type Operators in Orlicz Spaces.*

We study in the general setting of Orlicz spaces the problem of convergence and order of approximation for the following family of nonlinear integral operators

$$(T_w f)(s) = \int_H K_w(s - h_w(t), f(h_w(t))) d\mu_H(t), \ w > 0, \ s \in G, \quad \text{(I)}$$

where $G$ and $H$ are locally compact topological groups, $f : G \to \mathbb{R}$ is a measurable function, $\mu_H$ is the Haar measure on $\mathcal{B}(H)$, $\{h_w\}_{w>0}$ is a family of homeomorphisms $h_w : H \to h_w(H) \subset G$ and $\{K_w\}_{w>0}$ is a family of kernel functions. The general class (I) contains, as particular cases, several families of operators such as the nonlinear sampling-type operators, which have important applications in the field of signal processing and image analysis. (Received September 22, 2009)

1056-41-1903 **Terence G Hanchin*** (thanchin@kent.edu). *On Even and Odd Variation-Diminishing Convolution Transforms.*

A theorem of J.J. Sylvester gives an upper bound for the number of zeros, and hence sign changes, of a polynomial that can be written as a linear combination of shifted monomials having a common degree. If this common degree is even(odd), the upper bound is the smallest even(odd) number greater or equal to the number of sign changes in the sequence of coefficients of the linear transformation. This is an example of an *even(odd) variation-diminishing transformation.* Sylvester's Theorem can be extended to convolution on the real line with monomial kernels, and these transforms are also even(odd) variation-diminishing. We provide here a characterization of all kernels $\Lambda$ for which $f \to \Lambda * f$ is even or odd variation-diminishing. (Received September 22, 2009)

1056-41-2050 **Edmond J. Nadler*** (enadler@emich.edu), Mathematics Department, Eastern Michigan University, Ypsilanti, MI 48197. *Approximation by Bivariate Linear Splines on Triangulations.*

The setting is the approximation of a smooth bivariate function with polygonal domain by piecewise linear functions that are linear on each triangle in a triangulation of the domain, and the asymptotics as the number of triangles goes to infinity are considered. An asymptotic error estimate was obtained for best $L_2$ approximation in this setting, and used to characterize such an asymptotically optimal sequence of triangulations.

In this talk, early results by the author on this problem are reviewed, and extended to the more useful cases of *continuous* linear (approximating) splines and *interpolating* linear splines. (Received September 23, 2009)

1056-41-2143 **Yves Meyer*** (Yves.Meyer@cmla.ens-cachan.fr), ENS de Cachan, 61 av. President Wilson, 94235 CachanCedex, France. *Beyond the Shannon-Nyquist Theorem.*

We discuss recent results related to the title and their implications in signal processing and imaging. (Received September 23, 2009)

# 42 ► Fourier analysis

1056-42-280 **Jill Pipher*** (jpipher@math.brown.edu), Department of Mathematics, Brown University, Providence, RI 029012. *Weak Convergence in multiparameter Hardy spaces.*

In joint work with Sergei Treil, we prove the multiparameter analog of the Jones-Journe theorem on weak convergence in $H^1$ for the product Hardy space. (Received August 24, 2009)

1056-42-291 **Po Lam Yung***, Department of Mathematics, Princeton University, NJ 08544. *Sobolev Inequalities for $(0, q)$ forms on CR manifolds of finite type.*

Recently Bourgain-Brezis and Lanzani-Stein proved the following $L^1$ Sobolev inequality for differential forms on $\mathbb{R}^n$: If $u$ is a smooth compactly supported $q$ form on $\mathbb{R}^n$ and $q \neq 1$ nor $n-1$, then

$$\|u\|_{L^{\frac{n}{n-1}}(\mathbb{R}^n)} \lesssim \|du\|_{L^1(\mathbb{R}^n)} + \|d^*u\|_{L^1(\mathbb{R}^n)}.$$

I shall discuss an analogue of this result for the $\overline{\partial}_b$ complex on CR manifolds of finite commutator type. The main innovation here is a new kind of $L^1$ duality inequality for vector fields that satisfy Hormander's condition. (Received August 25, 2009)

1056-42-523 **Matthew Fickus*** (Matthew.Fickus@afit.edu), AFIT/ENC, 2950 Hobson Way, WPAFB, OH 45433, and **Amina Chebira** and **Dustin G. Mixon**. *Filter bank fusion frames.*

A fusion frame is a sequence of orthogonal projection operators whose sum can be inverted in a numerically stable way. When properly designed, fusion frames can provide redundant encodings of signals which are optimally robust against certain types of noise and erasures. However, up to this point, few implementable constructions of such frames were known; we show how to construct them using oversampled filter banks. To be precise, we first provide polyphase matrix-based characterizations of filter bank fusion frames. We then use these characterizations to construct fusion frame versions of discrete wavelet and Gabor transforms, emphasizing those specific filters whose frequency responses are well-behaved. (Received September 11, 2009)

1056-42-564 **John J. Benedetto*** (jjb@math.umd.edu), Norbert Wiener Center, Department of Mathematics, College Park, MD 20742. *A frame theoretic construction for spectral imaging data.* Preliminary report.

Motivated by hyperspectral and multispectral imaging problems, we construct a frame-based algorithm for dimension reduction and classification. The algorithm is formulated in terms of frame potential energy and constraint-based optimal frames. Sparse image representation is a key feature of the algorithm. (Received September 12, 2009)

1056-42-709 **Mukta B Bhandari*** (mukta@math.ksu.edu), 1544 International Court, Apt. # 23, Manhattan, KS 66502. *Good Lambda Inequality and Riesz potentials for Non Doubling Measures in $\mathbb{R}^n$.* Preliminary report.

We obtain Good Lambda Inequality for non doubling measures in $\mathbb{R}^n$ associated to Riesz Potentials. We also extend this to weight w associated to non doubling measure. We apply this to obtain Potential inequalities. Key words: maximal functions, fractional maximal functions, growth condition, Riesz potentials. (Received September 16, 2009)

1056-42-819 **Jean-Pierre Gabardo*** (gabardo@mcmaster.ca), Department of Mathematics & Statistics, 1280, Main Street West, Hamilton, Ontario L8S 4K1, Canada. *Irregular Gabor tight frames associated with rough windows.* Preliminary report.

The problem of constructing Parseval frames for $L^2(\mathbb{R}^n)$ of the form

$$\{\sqrt{c(x,\nu)}\, e^{2\pi it\nu}\, g(t-x)\}_{(x,\nu)\in\Lambda},$$

where $g \in L^2(\mathbb{R}^n)$ with $\|g\|_2 = 1$, $\Lambda$ is a discrete subset of the time-frequency space $\mathbb{R}^{2n}$ and $c(x,\nu) > 0$ for $(x,\nu) \in \Lambda$, leads naturally to the question of finding discrete positive measures $\mu$ on $\mathbb{R}^{2n}$ satisfying the identity

$$\int_{\mathbb{R}^{2n}} |V_g f(x,\nu)|^2\, d\mu(x,\nu) = \|f\|_2^2, \quad f \in L^2(\mathbb{R}^n),$$

where $V_g$ denotes the short-time Fourier transform with window $g$. When $g$ is a function in the Schwartz class $\mathcal{S}(\mathbb{R}^n)$, a recent result of the author shows that the isometric embedding above is equivalent to the identity $\mathcal{F}^S(\mu)\, V_g g = \delta_{(0,0)}$, where $\mathcal{F}^S(\mu)$ denote the symplectic Fourier transform of $\mu$. The focus of this talk will be to provide an alternative to this formula when $g$ is an arbitrary window in $L^2(\mathbb{R}^n)$ (in which case the distributional product in the previous formula no longer makes sense) and to discuss some of its consequences. (Received September 17, 2009)

1056-42-854 **Peter Casazza** and **Gitta Kutyniok*** (kutyniok@uni-osnabrueck.de), Institute for Mathematics, University of Osnabrueck, 49069 Osnabrueck, Germany. *A Quantitative Notion of Redundancy.*

The notion of redundancy is at the heart of frame theory. However, in the case of finite frames, no quantitative notion has been established yet. In this talk, we first introduce and discuss a list of desiderata a rationally defined quantitative notion of redundancy for a finite frame shall satisfy. We then propose a notion of upper and lower redundancy which, in particular, satisfies all properties advocated in the desiderata. (Received September 18, 2009)

1056-42-953 **Frederic Bernicot** (frederic.bernicot@math.univ-lille1.fr), CNRS & Universite Lille 1, Laboratoire de Mathematiques Paul Painleve, Villeneuve d'Ascq Cedex, 59655 , France, and **Rodolfo H. Torres*** (torres@math.ku.edu), Department of Mathematics, University of Kansas, 1460 Jayhawk Blvd, Lawrence, KS 66045-7594. *Sobolev space estimates for a class of bilinear pseudodifferential operators unbounded on Lebesgue spaces.*

The reappearance of a sometimes called exotic behavior of certain classes of pseudodifferential operators is investigated. The phenomenon is shown to be present in a recently introduced class of bilinear pesudodifferential operators, which can be seen as variable coefficient counterparts of the bilinear Hilbert transform and other singular bilinear multipliers operators. The unboundedness on product of Lebesgue spaces but the boundedness on spaces of smooth functions (which is the exotic behavior referred to) of such operators is obtained. (Received September 19, 2009)

1056-42-1003 **Izabella Laba** and **Malabika Pramanik*** (malabika@math.ubc.ca), 1984 Mathematics Road, Department of Mathematics, University of British Columbia, Vancouver, BC V6T 1Z2, Canada. *Multi-linear integrals associated to sparse subsets of $\mathbb{R}$.*

We discuss two results on sparse subsets of $\mathbb{R}$. The first concerns existence of three term progressions and the second boundedness of maximal operators and differentiation theorems. The common theme is the estimation of certain multi-linear integrals which play a critical role in both problems. This is joint work with Izabella Laba. (Received September 19, 2009)

1056-42-1087 **Judith A Packer*** (packer@colorado.edu), Department of Mathematics, CB 395, University of Colorado, Boulder, CO 80305. *Classification of filter systems giving rise to generalized multiresolution analyses.* Preliminary report.

We discuss how generalized multiresolution analyses (GMRAs)corresponding to a discrete abelian translation group $\Gamma$ and a dilation operator $\delta$ defined on abstract Hilbert spaces can be described by their multiplicity functions $m$ defined on $\widehat{\Gamma}$ and matrix-valued filter functions $H$ defined on appropriately chosen set related to $m$ and $\widehat{\Gamma}$. A construction procedure is described that produces an abstract GMRA from any functions $m$ and $H$ meeting required conditions. An equivalence relation is defined on different filter systems $H$ associated to the same multiplicity function $m$. We also discuss the isometry $S_H$ associated to the filter system $H$, a construction with its origins in the work of Bratteli and Jorgensen, and give necessary and sufficient conditions for this isometry to be pure. A few examples of frames related to these constructions will be given.

This work is joint with L. Baggett, V. Furst, and K. Merrill. (Received September 20, 2009)

1056-42-1145 **Alexander Powell*** (alexander.m.powell@vanderbilt.edu), Department of Mathematics, Vanderbilt University, Nashville, TN 37240, and **Christopher Heil** (heil@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332. *Regularity for exact Gabor systems on a lattice.*

The Balian-Low Theorem (BLT) is a strong form of the uncertainty principle for Gabor systems that form orthonormal bases or Riesz bases for $L^2(R)$. We investigate the Balian-Low theorem in the settings of (1) exact systems, and (2) Schauder bases. We prove a new nonsymmetrically weighted Balian-Low theorem for Gabor systems that are complete and minimal. We also discuss how Gabor Schauder bases relate to the Balian-Low theorem, and characterize a class of Gabor Schauder bases in terms of the Zak transform and product $A_2$ weights. (Received September 21, 2009)

1056-42-1207 **Camil Muscalu*** (camil@math.cornell.edu), Department of Mathematics, Cornell University, Ithaca, NY 14853. *On an interesting singular integral operator.* Preliminary report.

We shall describe the boundedness properties of a singular integral operator, which is of a different kind than the previously studied ones. (Received September 21, 2009)

1056-42-1360 **Q. Yen Do*** (qdo@math.ucla.edu), UCLA Department of Mathematics, 520 Portola Plaza, Math Sciences Building 6363, Los Angeles, CA 90095. *A nonlinear stationary phase method for oscillatory Riemann-Hilbert problems.* Preliminary report.

We extend a nonlinear stationary phase method initiated by Varzugin to study asymptotical behaviors of oscillatory Riemann-Hilbert problems arising in the theory of integrable systems, where the oscillating phase is not assumed to be analytic and has a finite number of stationary phase points of arbitrary orders. The main idea is to localize the given Riemann-Hilbert problem to small neighborhoods of stationary points, where the phase function could then be well-approximated by suitable analytic functions and thus allows for a steepest descent argument. (Received September 21, 2009)

1056-42-1455 **Michael Bateman*** (bateman@math.ucla.edu). *Maximal averages along one-variable vector fields.*

We prove $L^p$ estimates for a maximal operator along rectangles pointed in the direction of a vector field in $R^2$ depending on one variable. These estimates are related to the work of Lacey and Li on the Hilbert transform along vector fields. (Received September 21, 2009)

1056-42-1513 **Michael Christ*** (mchrist@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94720. *Upper Bounds for Multilinear Sublevel Sets.*

Let $\ell_j : \mathbb{R}^d \to \mathbb{R}^{d_j}$ be surjective linear transformations, let $P : \mathbb{R}^d \to \mathbb{R}$ be a real-valued polynomial, let $B$ be a ball in $\mathbb{R}^d$. The associated sublevel sets are

$$E_\varepsilon(P, g_1, \cdots, g_n) = \big\{y \in B : |P(y) - \sum_{j=1}^{n} g_j(\ell_j(y))| < \varepsilon\big\},$$

where $g_j : \mathbb{R}^{d_j} \to \mathbb{R}$ are arbitrary measurable functions. We study upper measure bounds of the form

$$\big|E_\varepsilon(P, g_1, \cdots, g_n)\big| \le \rho(\varepsilon)$$

which are uniform over all measurable functions $g_j$, with $\rho(\varepsilon) \to 0$ as $\varepsilon \to 0$. Such bounds would be implied by conjectured multilinear oscillatory integral inequalities. We prove the sublevel set bounds under the natural nondegeneracy hypothesis on $P$, supplemented by an auxiliary rationality hypothesis. The analysis involves an alternative notion called finitely witnessed nondegeneracy, and relies on a variant of Szemeredi's theorem due to Furstenberg and Katznelson. (Received September 22, 2009)

1056-42-1526 **Clifford J Nolan*** (clifford.nolan@ul.ie), Dept. of Maths and Stats, University of Limerick, Limerick, Limerick 00000, Ireland, and **Thomas Dowling** (thomas.dowling@ul.ie), Dept. of Maths and Stats, University of Limerick, Limerick, Limerick 00000, Ireland. *Imaging from Bistatic and Multiply Scattered Waves.*

We develop a new imaging technique that uses waves which scatter multiple times with either an unknown object of interest (to be imaged) or another known nearby scatterer.

In the context of RADAR imaging, radio waves are emitted from a moving air-borne antenna and its echoes are recorded. The data is collected over a range of positions (flight track) of the antenna. This so-called "Synthetic Aperture RADAR" (SAR) data is then processed by a "backprojection" method to obtain an image of the ground. SAR imaging doesn't account for waves that scatter multiple times.

We develop a model of the multiple scattering process which is encapsulated by a scattering operator:

$$F : \mathcal{E}'(X) \to \mathcal{E}'(Y)$$

where $X$ is the earth's surface and $Y$ is a set of points $(s, t)$ where $s$ denotes the current position of the antenna and $t$ the echo delay time. We show that $F$ is a Fourier integral operator with wavefront relation $\Lambda \subset T^*Y \times T^*X$. By analysing $\Lambda$ we devise a new technique which yields improved images and avoids artifacts that would be produced by traditional SAR imaging. (Received September 22, 2009)

1056-42-1632 **Xiaochun Li*** (xcli@math.uiuc.edu), Department of Math., UIUC, Urbana, IL 61822. *Bilinear Hilbert transforms along curves.*

We discuss the relation between bilinear Hilbert transforms along curves and the multilinear oscillatory integrals. (Received September 22, 2009)

1056-42-1651 **Michael Dabkowski*** (dabkowsk@math.wisc.edu), Department of Mathematics, University of Wisconsin, 480 Lincoln Dr., Madison, WI 53706-1388. *Regularization for Slightly Super Critical Surface Quasi-geostrophic Equation.*

We will prove that if the power on the fractional Laplacian is close enough to 1/2 and if non-linear component is a divergence free vector field with uniformly bounded BMO norm, then we can estimate the Holder norm of the solution uniformly. We will prove this using the duality approach of Nazarov and Kiselev. (Received September 22, 2009)

1056-42-1657 **Alberto A. Condori*** (condori@rose-hulman.edu), Department of Mathematics, Rose-Hulman Institute of Technology, 5000 Wabash Avenue, Terre Haute, IN 47803. *An index formula in connection with meromorphic approximation.* Preliminary report.

This talk is about Harmonic Analysis of Operators on Hilbert spaces. We introduce the so-called Nehari-Takagi problem, its superoptimal solutions and provide a characterization of bounded functions that have a unique meromorphic approximation with a prescribed McMillan degree. For these functions, we introduce an index formula that shows a connection between Toeplitz operators, Hankel operators and the McMillan degree. Moreover, we provide an example of how this formula can be used to study perturbation of singular values of Hankel operators. (Received September 22, 2009)

1056-42-1758 **Ronny Hadani*** (hadani@math.utexas.edu), 1 University station C1200, Austin, TX, and **Shamgar Gurevich** and **Nir Sochen**. *Group representation patterns in digital signal processing.*

In the lecture I will explain how various fundamental structures from group representation theory appear naturally in the context of discrete harmonic analysis and can be applied to solve concrete problems from digital signal processing. specifically, I will describe a solution to the problem of finding a canonical orthonormal basis of eigenfunctions for the discrete Fourier transform (DFT). Then I will explain how to generalize the construction to obtain a larger collection of functions that we call "The oscillator dictionary". Functions in the oscillator dictionary admit many interesting properties, which are appealing to various area of digital signal processing. (Received September 22, 2009)

# 43 ► Abstract harmonic analysis

1056-43-755 **Azita Mayeli*** (amayeli@math.sunysb.edu), Mathematics Department, Room N707, New York City College of Technology, 300 Jay Street, Brooklyn, NY 11201. *Multiresolution Shannon-type wavelet on the Heisenberg group.*

Multiresolution Analysis (MRA) is a mathematical tool for the construction of orthonormal wavelet bases for $L^2(\mathbb{R}^n)$. Motivated by MRA in the Euclidean setting, in this talk I will present a notion and then a concrete example of a multiresolution analysis on the Heisenberg group $\mathbb{H}$. For our example, in contrast to the usual approach on $\mathbb{R}^n$, we start with construction of a sinc-type function using the group Fourier transform. As we will discuss, the sinc-type function implies the existence of a band-limited scaling function in a shift-invariant and closed subspace of $L^2(\mathbb{H})$ and hence the existence of a Parseval frame for $L^2(\mathbb{H})$. We call the generator of this frame a Shannon-type wavelet on $\mathbb{H}$. (Received September 16, 2009)

1056-43-1059 **Hans G. Feichtinger*** (hans.feichtinger@univie.ac.at), Fac. of Math., Univ. Austria, NuHAG, Alserbachstr. 23, Vienna, Austria. *Group theoretical aspects of Gabor Analysis.* Preliminary report.

Gabor Analysis is a particular branch of time-frequency analysis, and as such a flourishing part of mathematical analysis, but also highly relevant for signal processing applications. As opposed to the reconstruction of a function or distribution from its continuous short-time Fourier transform, or alternatively the representation of functions as a continuous superposition of coherent states, Gabor analysis makes use of discrete lattices in phase space.

There is a lot of analyis going on in Gabor analysis (Weyl-Heisenberg frames are used for signal expansions, Weyl-Heisenberg Riesz basis are used for communication, corresponding matrix representations of slowly varying channels are helpful in the design of better decoders), but some of the key results in Gabor analysis (such as the existence of dual windows, generating the dual frame, etc.) can be described at a purely algebraic level, making use of intertwining properties, commutation relations, covariance properties, and so on, which can be formulated in the setting of finite Abelian groups.

We will give a summary of such properties, emphasizing the algebraic side of Gabor analysis, which in fact is also the basis for implementations and fast algorithms. (Received September 20, 2009)

1056-43-1347 **Jessica A Spicer*** (jexica11@gmail.com), 1635 W Neptune Dr Apt 2, Fayetteville, AR 72701, and **Samuel J Ferguson** (sjfergus@email.unc.edu). *Convex Combinations of Harmonic Mappings to Regular Polygons.*

Using the work of Dorff, Taylor, and Woloszkiewicz, one may create new univalent harmonic mappings from the convex combinations of harmonic mappings of m regular 2n-gons that satisfy certain conditions. Such univalent convex combinations with square dilatations may then be raised to minimal graphs via the Weiestrass Representation. Certain properties of the shape resultant minimal graph may then be inferred from the original convex combination of m regular 2n-gons. Finally, the possibility of combining a regular 2n and 3n-gon and a 2n, 3n, and 4n-gon is discussed. (Received September 21, 2009)

1056-43-1718 **Emily J King*** (kingej@mail.nih.gov), 6737 Village Park Dr, Greenbelt, MD 20770, and **Wojciech Czaja**. *Generalized shearlets and the extended metaplectic group.*

Typically, multidimensional data has been analyzed using tensor products of 1-dimensional wavelets; however, these methods do not yield any information about directional components or trends. A number of new representations have sprung up in an attempt to solve this problem, including shearlets, for which nice algorithms and theory exist. Shearlets are used to analyze 2-dimensional data sets, but there is a need to develop higher dimensional tools for various applications, like in biomedical imaging. Inspired by the work of Cordero, DeMari, Nowak, and Tabacco, we exploit the representation theory of the extended metaplectic group in order to construct isotropic and anisotropic analogs of the shearlet transform over $L^2(R^d)$ for $d \geq 2$. (Received September 22, 2009)

1056-43-1816 **Adam W Parr*** (aparr@uvi.edu), UVI, 2 John Brewers Bay, St Thomas, VI 00802. *Generalized Convolution Systems: Axioms and Properties.*

A convolution, $*$, is a binary operation that plays a multiplication-style role on the space $M_b(X)$ of bounded measures on a locally compact space $X$. Convolutions of measures arise naturally from the study of topological groups. The study of topological groups leads to spaces that do not have a group structure, but do have a well-defined convolution of measures similar to what arises with groups. We investigate properties that are commonly used as axioms for hypergroup type convolution systems. A comparison of axiomatic structures used by signed hypergroup authors will be made, and an example will be given of a hypergroup whose dual satisfies all properties except for norm-bounding. (Received September 22, 2009)

# 45 ▶ Integral equations

1056-45-1010 **Z Dai*** (dai@alma.edu) and **P K Lamm**. *On the Nonpositive Solution of the Nonlinear Inverse Autoconvolution Problem.*

Local regularization methods preserve the causal nature of Volterra problems, allowing for fast sequential numerical solution techniques. Stability and convergence of these methods were shown to hold not only on a large class of linear Volterra problems, but also on nonlinear Volterra problems of Hammerstein type and the nonlinear autoconvolution problems. Local regularization methods compare favorably to the exisitng methods in the literature for the autoconvolution problem (such as Tikhonov regularization and Lavrent'ev regularization), especially in recovering sharp features of the unknown solution. It is also worth noting that local regularization methods do not require an initial guess of the unknown solution. A local regularization theory was developed by the authors in solving positive unknown solutions of the autoconvolution problem, in the case of $L_2$ or continuous data. Numerical results demonstrated the effectiveness of the local regularization methods even when the unknown solutions failed to be strictly positive, while the theory was limited to positive solutions only. In this presentation, we will establish the local regularization theory to solve for nonpositive solutions of the autoconvolution problem, allowing for $L_P$ data, where $1 \leq P \leq \infty$. (Received September 19, 2009)

1056-45-1025 **Jang Bongsoo*** (bsjang@unist.ac.kr), School of Mechanical & Advanced Material Eng, Ulsan National Institue of Science, and Technology(UNIST), Ulsan Metropolitan, South Korea. *Solving two-dimensional linear and nonlinear Volterra integral equations by the differential transform method.*

We present some fundamental properties of the differential transform method(DTM) for the several kernel functions in two-dimensional Volterra integral equations. The product and quotient type's kernel functions are considered. All proofs are derived by the simple properties for the DTM. Several illustrative examples are demonstrated to show the effectiveness of the DTM for solving two-dimensional Volterra integral equations. (Received September 20, 2009)

# 46 ▶ Functional analysis

1056-46-21 **NasirUddin Ahmed*** (ahmed@site.uottawa.ca), SITE, 800 King Edward Street, University of Ottawa, Ottawa, Omtario K1N6N5, Canada. *Weak compactness in the space of Operator Valued Measures $M_{ba}(\Sigma, \mathcal{L}(X, Y))$ with an Application.* Preliminary report.

In this paper we present necessary and sufficient conditions for conditional weak compactness in the space of operator valued measures $M_{ba}(\Sigma, \mathcal{L}(X, Y)$ with an application to partially observed stochastic differential equations on infinite dimensional Hilbert spaces.

**Theorem 1** Let $S$ be a compact Hausdorff space and $\Sigma$ the sigma algebra of subsets of the set $S$. Let $\{X, Y\}$ be a pair of Banach spaces with $Y$ being reflexive and consider the space of operator valued measures $M_{ba}(\Sigma, \mathcal{L}(X, Y))$. A set $\Gamma \subset M_{ba}(\Sigma, \mathcal{L}(X, Y))$ is conditionally weakly compact if, and only if, the following conditions hold:

(i): $\Gamma$ is bounded, that is, $\sup\{\hat{T}(S), T \in \Gamma\} < \infty$, with $\hat{T}$ denoting the semivariation of $T$,

(ii): for each $f \in B_\infty(S, X)$, the set of measures $\{v(\mu)(\cdot) \equiv |\mu|(\cdot) : \mu \in \Gamma(f)\}$ where $\Gamma(f) \equiv \{\mu : \mu(\sigma) \equiv (Tf)(\sigma), \sigma \in \Sigma\}$, is uniformly additive.

**Application**: This result is applied to structural control of partially observed stochastic systems on Hilbert spaces with nonstandard cost functional. (Received May 10, 2009)

1056-46-88 **Robert G. Fraser*** (rgf11@cwru.edu), **Andrew Dugowson** and **Yeonhyang Kim**. *Modulation Frames and Infinite Symmetric Matrices.*

Let $H$ be a separable Hilbert space. A set $\{f : k \in \mathbb{Z}\} \subset H$ is a frame for $H$ if there exist constants $A, B > 0$ such that for all $f \in H$,

$$A\|f\|_H^2 \leq \sum_{k\in\mathbb{Z}} |\langle f, f_k\rangle|^2 \leq B\|f\|_H^2.$$

In this paper, we introduce modulation frames, which consist of modulates of functions in $L_2(\mathbb{R})$. We characterize these frames using infinite symmetric matrices. Theses matrices can be used to generalize the relationship between Weyl-Heisenberg frames and infinite quadratic forms. (Received July 24, 2009)

1056-46-258 **Hueytzen J Wu*** (kfhjw00@tamuk.edu), Department of Mathematics, Texas A & M University - Kingsville, Kingsville, TX 78363-8202, and **Wan-Hong Wu** (dd1273@yahoo.com), 7703 Floyd Curl Drive, San Antonio, TX 78229. *A Generalized Ston-Wierstrass theorem for Cz-vector lattices and Cz-algebras.* Preliminary report.

By defining an equivalence relation on an arbitrary topological space Y, a Tychonoff space X is induced such that there is an isometry G from C*(X) to C*(Y), where both C*(X) and C*(Y) are equipped with the supremum norm. For any Hausdorff compactifica- tion (Z, h) of the Tychonoff space X induced by Y, let S be the set of all f o h for f in C(Z), and T be the set of all G(g) for g in S. Then S and T are a complete vector sublattice and complete subalgebra of C*(X) and C*(Y), respectively. T will be called a Cz-vector lattice or a Cz-algebra on Y. A sufficient and necessary condition for any vector sublattice or subalgebra V of T to be dense in T is provided. If Y is Tychonoff, then Y = X and if (Z, h) is the Stone-Cech compactification of X, then T = C*(X) = C*(Y) and an extension of the generalized Stone-Weierstrass theorem with a sufficient and necessary condition to C*(X) is achieved. (Received August 21, 2009)

1056-46-515 **Aidan Sims*** (asims@uow.edu.au), School of Mathematics and Applied Statistics, Austin Keane Building (15), The University of Wollongong, Wollongong West, NSW 2522, Australia. *Structure theory for k-graph $C^*$-algebras.*

There are a great many beautiful structure theorems for graph $C^*$-algebras. They frequently involve surprisingly elementary graph-theoretic conditions, most notably to do with loops in graphs. In particular, there are elementary conditions which characterise when a graph $C^*$-algebra is simple, when it is AF, and when it is purely infinite; and all of these conditions relate to whether or not the graph contains a loop, and if so whether the loop has an entrance.

For $k$-graph $C^*$-algebras, the situation is much more complicated, at least in part because there are many different types of loops that can occur. This has made it very difficult to characterise simple $k$-graph algebras, and the question of precisely which $k$-graph $C^*$-algebras are AF remains open. Moreover, until recently, many of the conditions on $k$-graphs appearing in structure theorems have related to infinite paths, which are themselves complicated and difficult to work with in the higher-rank setting.

We give an overview recent results with David Robertson and with Peter Lewin which characterise simplicity of $k$-graph algebras using elementary conditions involving finite paths. We also discuss recent work with Gwion Evans towards characterising which a $k$-graph $C^*$-algebras are AF. (Received September 11, 2009)

1056-46-535 **Bernhard G Bodmann*** (bgb@math.uh.edu), 651 PGH, Department of Mathematics, University of Houston, Houston, TX 77204, and **Peter G Casazza**. *Distance estimates and a flow converging to equal-norm Parseval frames.*

We present bounds for the distance between the set of equal-norm Parseval frames and a frame which is nearly Parseval and has approximately equal-norm vectors. The lower bound on the distance results from variational inequalities. The upper bound uses a family of ordinary differential equations for Parseval frames and a related flow which can be shown to converge to an equal-norm Parseval frame, if the number of vectors in a frame and the dimension of the Hilbert space they span are relatively prime, and if the initial frame consists of vectors having sufficiently nearly equal norms. (Received September 11, 2009)

1056-46-635 **Peter G. Casazza*** (casazzap@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211-4100, **Bernhard G. Bodmann**, Department of Mathematics, University of Houston, Houston, TX 77204, **Vern I. Paulsen**, Department of Mathematics, University of Houston, Houston, TX 77204, and **Darrin Speegle**, Department of Mathematics, St. Louis University, St. Louis, MO 63103. *Spanning Properties of Frames.*

We answer a number of open problems in frame theory concerning the decomposition of frames into linearly independent and/or spanning sets. (Received September 15, 2009)

1056-46-726 **Antonia E Cardwell*** (antonia.cardwell@millersville.edu), Department of Mathematics, Millersville University, P. O. Box 1002, Millersville, PA 17551. *Path-connectedness of the space of norm-attaining functionals on certain Banach spaces.*

Consider the space of norm-one norm-attaining functionals on a Banach space $X$ given by $\mathcal{A} = \{\varphi \in X^* : \|\varphi\| = 1 \text{ and } \varphi \text{ is norm-attaining}\}$. A characterization of the functionals in $\mathcal{A}$ will be given for the Banach spaces $c_0$ (real and complex), $\ell_1$ (real and complex) and $C[a, b]$ (for $-\infty < a < b < \infty$.) This characterization will then be used to prove constructively that $\mathcal{A}$ is path-connected for the above-mentioned Banach spaces. (Received September 16, 2009)

1056-46-761 **Palle E. T. Jorgensen***, Dept Math MLH, University of Iowa, Iowa City, IA. *Frames for $L^2$ of measures with scale self-similarity.* Preliminary report.

In the talk we present some results on spectral theory and harmonic analysis of measures with scale self-similarity. This will be from joint papers with several co-authors, D. Dutkay, S. Pedersen, K. Kornelson, K. Shuman. We further show that in this context, issues of a priori estimation of frame bounds entails new tools typically not used in more traditional approaches. A connection between this and the Kadison-Singer conjecture will be mentioned. (Received September 16, 2009)

1056-46-781 **Dorin Dutkay***, UCF, Department of Mathematics, Orlando, FL 32816. *Can one hear the shape of a fractal?*

We show how the spectral data contained in the Fourier series can be used to determine geometric properties of a fractal measure. In particular, we show that the Beurling dimension of a Fourier frame is equal to the Hausdorff dimension of the fractal. (Received September 17, 2009)

1056-46-911 **Cynthia Farthing*** (CynthiaFarthing@creighton.edu), Department of Mathematics, 2500 California Plaza, Omaha, NE 68178. *Desingularization technique for higher-rank graphs.*

Given a higher-rank graph $\Lambda$, it is possible to construct a higher-rank graph $\overline{\Lambda}$ that has no sources and contains $\Lambda$ as a subgraph. Furthermore, if $\Lambda$ is row-finite, then the $C^*$-algebra associated to $\overline{\Lambda}$ is Morita equivalent to the $C^*$-algebra of the original graph $\Lambda$.

In this talk, we will outline the process used to remove sources from higher-rank graphs and discuss some applications where removing sources is useful. We will also discuss infinite receivers in $k$-graphs and any progress made on desingularizing these vertices. (Received September 18, 2009)

1056-46-924 **Shukhrat M Usmanov*** (Shukhrat.Usmanov@yahoo.com), Ashford University, Dept of Math and Computer Science, 400, N. Bluff Blvd, Clinton, IA 52732. *Dominated Ergodic Theorem for isometries of non-commutative $L_p$-spaces,* $1 < p < \infty$. Preliminary report.

We prove the dominated ergodic theorem for positive invertible isometries of the non-commutative $L_p$-spaces associated with finite von Neumann algebras. As a corollary, we obtain the individual ergodic theorem for such isometries. (Received September 18, 2009)

1056-46-959 **Gene Abrams** and **Mark Tomforde*** (tomforde@math.uh.edu). *Isomorphism and Morita equivalence of graph algebras I.*

In this talk we consider Leavitt path algebras and graph $C^*$-algebras, and we discuss various relationships between the algebras in these two classes. We describe how the Leavitt path algebra $L_{\mathbb{C}}(E)$ is canonically isomorphic to a dense $*$-subalgebra of $C^*(E)$, discuss the implications of this imbedding, and examine a number of similar results for these two classes. We shall also discuss the problem of lifting and restricting isomorphisms between graph algebras, and consider two questions: (1) If $L_{\mathbb{C}}(E)$ and $L_{\mathbb{C}}(F)$ are isomorphic as rings, does it follow that $C^*(E)$ and $C^*(F)$ are isomorphic as $C^*$-algebras? and (2) If $L_{\mathbb{C}}(E)$ and $L_{\mathbb{C}}(F)$ are Morita equivalent as rings, does it follow that $C^*(E)$ and $C^*(F)$ are Morita equivalent as $C^*$-algebras? (Received September 18, 2009)

1056-46-1032 **Alexander A. Katz** (katza@stjohns.edu), St. John's University, Dep. of Math & CS, 300 Howard Ave., DaSilva 314, Staten Island, NY 10301, **Roman Kushnir** (kushnir_roman@yahoo.com), University of South Africa, Department of Mathematical Sciences, P.O.Box 392, Pretoria, 0003, and **Mark Ustayev*** (mark.uuuu@gmail.com), University of South Africa, Department of Mathematical Sciences, P.O.Box 392, Pretoria, 0003. *On real, Jordan and Lie structures in locally W*-algebras.*

We discuss real *-, Jordan and Lie subalgebras of topological *-algebras which are projective limits of projective families of complex W*-algebras. Various abstract characterizations of these algebras are studied and various theorems on their representations are obtained. (Received September 22, 2009)

1056-46-1079 **Gestur Olafsson*** (olafsson@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, and **Jens Christensen**. *Function spaces and representations.*

We present an abstract framework for construction of Banach spaces of distributions from group representations. Spaces that can be described by this technique include the whole Banach-scale of Bergman spaces and Besov spaces on the light cone. We show that atomic decompositions can be constructed through sampling. (Received September 20, 2009)

1056-46-1211 **Dawn Archey*** (archey@math.bgu.ac.il). *Crossed product $C^*$-algebras by finite group actions with the projection free tracial Rokhlin property.*

We introduce an analog of the tracial Rokhlin property, called the *projection free tracial Rokhlin property*, for $C^*$-algebras which may not have any nontrivial projections. Using this we show that if $A$ is an infinite dimensional stably finite simple unital $C^*$-algebra with stable rank one, with strict comparison of positive elements, with a unique tracial state, and with the property that every 2-quasi-trace is a trace, and if $\alpha$ is an action of a finite group $G$ with the projection free tracial Rokhlin property, then the crossed product $C^*(G, A, \alpha)$ also has stable rank one. (Received September 21, 2009)

1056-46-1261 **Matthew A. Fury*** (mfury@brynmawr.edu). *Continuous Dependence Results for Ill-posed Evolution Problems in a Banach Space.*

We prove Hölder-continuous dependence results for the difference between certain ill-posed and well-posed evolution problems in a Banach space $X$. We consider the ill-posed evolution problem

$$\begin{aligned} \frac{du(t)}{dt} &= A(t,D)u(t) \qquad 0 \le t < T \\ u(0) &= \chi, \end{aligned} \tag{1}$$

where $iD$ is the generator of a bounded strongly continuous group on $X$, and $A(t,D) = \sum_{j=1}^{k} a_j(t)D^j$ with $a_j \in C([0,T] : \mathbb{C})$ for each $1 \le j \le k$. We determine families $\{f(t,D)\}_{t\in[0,T]}$ of operators in $X$ such that the problem

$$\begin{aligned} \frac{dv(t)}{dt} &= f(t,D)v(t) \qquad 0 \le t < T \\ v(0) &= \chi \end{aligned} \tag{2}$$

is well-posed and such that solutions of the well-posed problem (2) approximate known solutions of the original ill-posed problem (1). We use $C$-regularized evolution systems to obtain our approximation which establishes continuous dependence on modeling for the problems under consideration. Namely, assuming $u(t)$ and $v(t)$ are solutions of (1) and (2) respectively, we prove that

$$\|u(t) - v(t)\|_1 \le C_1 \beta^{1-\frac{t}{T}} M^{\frac{t}{T}}$$

for a suitable norm $\|\cdot\|_1$, where $0 < \beta < 1$, and $C_1$ and $M$ are constants independent of $\beta$. (Received September 21, 2009)

1056-46-1291 **Sonia Sharma*** (sonia@math.uh.edu), Department of Mathematics, University of Houston, Houston, TX 77204. *Operator spaces with an ideal structure.*

The notion of an ideal is an essential algebraic notion in ring theory and algebra. The theory of ideals has been generalized to the non-algebraic setting of Banach spaces in more than one way. One of the more successful and vastly studied notion of ideals is that of "$M$-ideals". A particular class of $M$-ideals that has been extensively studied in the Banach space literature, are the spaces that are $M$-ideals in their second dual $X^{**}$. Recall, every Banach space $X$ can be thought of as a subspace of its second dual, $X^{**}$, via a canonical embedding $X \hookrightarrow X^{**}$. We have developed a non-commutative generalization of the above class, namely the theory of operator spaces which are 'ideals' in their second dual. We will talk about some of the interesting features and examples of these spaces. (Received September 21, 2009)

1056-46-1302 **Carlo Morpurgo*** (morpurgoc@missouri.edu), Department of Mathematics, 121 Math. Sciences Bldg., University of Missouri, Columbia, MO 65203, and **Luigi Fontana**. *Exponential integrability: a unified approach.*

We present new theorems regarding inequalities of type

$$\int_N \exp\left[\left(A\frac{|Tf(x)|}{\|f\|_p}\right)^{p'}\right] d\nu(x) \le C$$

where $Tf(x) = \int_M K(x,y)f(y)d\mu(y)$, and $(M,\mu)$ and $(N,\nu)$ are measure spaces with finite measure. Under suitable growth conditions on the kernel $K$, given in terms of its distribution function, the above inequality holds for all $f \in L^p(M)$ ($p > 1$ and $p'$ its conjugate exponent); the constant $A$ is explicitly related to the growth of the kernel.

This type of inequality was first derived on bounded domains of $\mathbb{R}^n$ by David Adams, in his proof of the sharp Moser-Trudinger inequality for higher-order gradients.

We present some new applications of our general theorems, in the form of sharp Moser-Trudinger inequalities in various settings. (Received September 21, 2009)

1056-46-1552 **Genady Ya. Grabarnik** (genadyg@hotmail.com), York College, CUNY, 94 - 20 Guy R. Brewer Blvd., Dep. of Math. & Comp. Studies, Jamaica, NY 11451, **Alexander A. Katz*** (katza@stjohns.edu), St. John's University, Dep. of Math & CS, 300 Howard Avenue, DaSilva 314, Staten Island, NY 10301, and **Laura Shwartz** (lshwart@us.ibm.com), IBM T.J. Watson Research Center, 19 Skyline Drive, Hawthorne, NY 10532. *On a reduction method for nonassociative $L_p$-spaces.*

Following ideas of Haagerup, Junge and Xu we consider the reduction of problems on general nonassociative $L_p$-spaces to the corresponding ones on those associated with finite JBW algebras. As it was in the case of von Neumann algebras, the main tool is an analogy of an unpublished result of Haagerup which approximates any noncommutative $L_p$-space by tracial ones. We show that under some natural conditions a map between two JBW-algebras extends to the crossed products of their enveloping von Neumann algebras by a locally compact abelian group or to their nonassociative $L_p$-spaces. (Received September 22, 2009)

# 47 ► Operator theory

1056-47-110 **Anna Skripka*** (askripka@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843. *Traces of operator derivatives.* Preliminary report.

For a large class of admissible scalar functions $f$, we obtain scalar integral representations for operator derivatives $\frac{d^k}{dt^k}f(H_0+tV)$ inside a normal faithful semi-finite trace $\tau$, with an initial operator $H_0$ belonging to a semi-finite von Neumann algebra $\mathcal{A}$, an increment $V$ to a $\tau$-Hilbert-Schmidt class of $\mathcal{A}$, and the values of $k$ determined by further properties of $\mathcal{A}$. These representations imply, in particular, that computation of $\tau\left[\frac{d^k}{dt^k}f(H_0+tV)\right]$ can be reduced to the computation of $\frac{d^{k-1}}{dt^{k-1}}f'(H_0+tV)$ and that the remainder of a Taylor-type approximation $\tau\left[f(H_0+V)-\sum_{k=0}^{p-1}\frac{1}{k!}\frac{d^k}{dt^k}\big|_{t=0}f(H_0+tV)\right]$ is a bounded functional on $f^{(p)}$. (Received July 27, 2009)

1056-47-217 **Sarah E. Wright*** (sarah.e.wright@dartmouth.edu). *Aperiodicity in Topological $k$-Graphs.* Preliminary report.

I will define and discuss topological $k$-graphs, a generalization of both Katsura's well known topological graphs as well as the discrete $k$-graphs defined by Kumjian and Pask. As in discrete $k$-graphs, the notion of aperiodic paths plays an important roll in the study of the $C^*$-algebras of higher-rank topological graphs. I will give a generalization of the infinite aperiodicity condition of discrete $k$-graphs, show some equivalent finite conditions that are more manageable, and discuss how these conditions lead to theorems of uniqueness and simplicity. (Received September 21, 2009)

1056-47-309 **Robert F. Allen*** (allen.rob3@uwlax.edu), Department of Mathematics, University of Wisconsin – La Crosse, La Crosse, WI 54601, and **Flavia Colonna** (fcolonna@gmu.edu), Department of Mathematical Sciences, George Mason University, Fairfax, VA 22030. *Weighted Composition Operators from $H^\infty$ to the Bloch Space of a Bounded Homogeneous Domain.* Preliminary report.

We investigate the weighted composition operators from the Hardy space $H^\infty$ into the Bloch space of a bounded homogeneous domain. We characterize boundedness, give sufficient conditions for compactness, and establish operator norm estimates. Lastly, we study the component multiplication and composition operators from $H^\infty$ to the Bloch space of $D$, and show that there are no isometries among these operators. (Received August 27, 2009)

1056-47-322 **Akram Aldroubi*** (akram.aldroubi@vanderbilt.edu), Dept. of Mathematics, Vanderbilt University, Nashville, TN 37240, and **Romain Tessera**. *Sparse approximations and the minimum subspace approximation property.*

Let $\mathcal{C}$ be a set of closed subspaces of a separable Hilbert space $\mathcal{H}$. We find a topological characterization of the following property of $\mathcal{C}$ : for every finite subset $F\subset\mathcal{H}$, there exists a subspace $V^o\in\mathcal{C}$ that minimizes the expression

$$\sum_{f\in F} d^2(f,V), \tag{1}$$

over all $V\in\mathcal{C}$. We say that $\mathcal{C}$ has *MSAP* (MSAP stands for Minimum Subspace Approximation Property) if that property holds for all finite subsets $F$. The MSAP has applications in sparse approximation, compressed sampling, dictionary design, and the Generalized Principle Component Analysis. (Received August 28, 2009)

1056-47-328 **Joseph A. Ball*** (joball@vt.edu), Department of Mathematics, Virginia Tech, Blacksburg, VA 24061-0123, and **Sanne ter Horst** (s.terhorst@math.uu.nl), Department of Mathematics, Utrecht University, Budapestlaan 6, 33584 CD, Utrecht, Netherlands. *Nevanlinna-Pick interpolation for the Schur class associated with a directed graph.*

The theory of Nevanlinna-Pick and Carathéodory-Fejér interpolation for matrix- and operator-valued Schur class functions on the unit disk is now well established. P.S. Muhly and B. Solel recently introduced a notion of Schur class and associated Nevanlinna-Pick interpolation theory in the context of a Fock space built from a $W^*$-correspondence $E$ over a $W^*$-algebra $\mathcal{A}$ and a $*$-representation $\sigma$ of $\mathcal{A}$. In addition to the classical case, a particular instance of this setting is a Schur class equal to the unit ball of the Toeplitz algebra associated with a directed graph (or quiver). In this talk we make explicit the content of the Nevanlinna-Pick interpolation theory for this setting and discuss connections with other recent work on generalized Schur classes and interpolation theory. (Received August 29, 2009)

1056-47-577 **Dhruba R Adhikari*** (dadhikari@as.muw.edu), 1100 College Street, MUW-100, Columbus, MS 39701, and **Athanassios G Kartsatos**. *Eigenvalues for Perturbations of Densely Defined Linear Maximal Monotone Operators.* Preliminary report.

Let $X$ be a real reflexive Banach space with dual $X^*$. Let $L : X \supset D(L) \to X^*$ be densely defined linear maximal monotone. Let $T : X \supset D(T) \to 2^{X^*}$ be maximal monotone with $0 \in \overset{\circ}{D}(T)$ and $0 \in T(0)$, and $C : X \supset D(C) \to X^*$ bounded demicontinuous and of type $(S_+)$ w.r.t. $D(L)$. An eigenvalue problem of the type $Lx + Tx + C(\lambda, x) \ni 0$ is solved, where $C(\cdot, x)$ is as above w.r.t. the variable $x$. The recent topological degree theory of the authors is used, utilizing the graph norm topology on $D(L)$, along with the methodology of Berkovits and Mustonen and recent invariance of domain and eigenvalue results by Kartsatos and Skrypnik. (Received September 13, 2009)

1056-47-1005 **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 induced diffusion distance.* Preliminary report.

For $M$ a manifold, let $\rho_t(x, y)$ denote a non-negative kernel on $M \times M$ satisfying the semi-group property in time $t$. Peter Jones has proposed the following natural measure of discrepancy between two points $x$ and $y$ in $M$: for a fixed paramter $\omega$ with $0 < \omega < 1$,

$$\tau(x, y) = \operatorname{argmin}_t \left\{ \int_M \min(\rho_t(u, x), \rho_t(u, y))\, du \geq \omega \right\},$$

i.e. $\tau(x, y)$ is the first time that the two "bump" functions centered at $x$ and $y$, respectively, significantly overlap. In the case of heat flow on $\mathbb{R}^n$, $\tau(x, y)$ is a scaled square of the usual Euclidean distance; in particular, $\tau(\cdot, \cdot)$ does not satisfy the triangle inequality.

We propose a general construction which modifies $\tau(x, y)$ so that the result does satisfy the triangle inequality (with possible minor exceptions), and hence is (almost) a metric. In the case of heat flow on $\mathbb{R}^n$, our method recovers scaled Euclidean distance. (Received September 19, 2009)

1056-47-1008 **Boubakari Ibrahimou*** (bibrahimou@murraystate.edu), Department of Mathematics & Statistics, Murray State University, Faculty Hall Room 6C, Murray, KY 42071. *The Generalized Degree for Multifunctions Perturbations of Maximal Monotone Operators and Applications.*

The main purpose of this paper is to develop a topological degree for mappings of the form $T - G$ where $T$ is a maximal monotone operator and $G$ a multifunction of class $(P)$ as extension of the degree for $A - G$ developed by Chen where $A$ is m-accretive. We first construct the degree for mappings of the form $\lambda J + T - G$. Next we construct the new topological degree and discuss some applications in mapping theorems. (Received September 19, 2009)

1056-47-1062 **Teresa Bates**, **David Pask** and **Paulette N. Willis*** (pnwillis@math.uiowa.edu), 70 Cherry Ct., Apt 2, North Liberty, IA 52317. *Labeled Graph $C^*$-algebras with Group Actions.*

In this presentation, I will discuss joint work with Teresa Bates and David Pask concerning (discrete) group actions on labeled graphs and the resulting crossed product $C^*$-algebras. In particular, I will discuss a version of the Gross-Tucker Theorem for labeled graphs. I will also discuss analogues of some of our results in the context of Leavitt path algebras.

A *labeled graph* $(E, \mathcal{L})$ over an alphabet $\mathcal{A}$ consists of a directed graph $E$ together with a labeling map $\mathcal{L} : E^1 \to \mathcal{A}$. One can associate a $C^*$-algebra to a labeled graph $(E, \mathcal{L})$ in such a way that if the labeling $\mathcal{L}$

is trivial then the resulting $C^*$-algebra is the $C^*$-algebra of the graph $E$. Further, just as there is a canonical correspondence between graph $C^*$-algebras and shifts of finite type, there is a similar correspondence between the $C^*$-algebras of labeled and sophic shifts. (Received September 20, 2009)

1056-47-1084 **Victor Kaftal*** (kaftal@math.uc.edu) and **David R Larson** (larson@math.tamu.edu).
*Perturbations of finite frames and projections.*

We present an algorithm for perturbing finite frames of Hilbert space vectors into new frames with assigned vector lengths and with the same frame operator.

If no two vectors of the original frame are orthogonal then we have control on the distance of the two frames. For instance if we start with a Parseval frame where the variation of the norms of the vectors is sufficiently small and the angle between the vectors is sufficiently far from $\frac{\pi}{2}$, then our algorithm provides an equal norm Parseval frame close to the original frame.

The algorithm is based on matricial techniques combined with convexity methods from majorization theory. (Received September 20, 2009)

1056-47-1091 **Keri Kornelson*** (kkornelson@math.ou.edu), **Palle Jorgensen** and **Karen Shuman**.
*Spectral sets for $\frac{1}{2n}$-Bernoulli convolutions.*

Bernoulli convolution measures $\mu_\lambda$ arise from an iterated function system of 2 affine maps on the real line: $\tau_\pm(x) = \lambda(x \pm 1)$. We examine maximal orthogonal sets and orthonormal bases of exponential functions with respect to the Hilbert space $L^2(\mu_\lambda)$ with parameter $\lambda = \frac{1}{2n}$. We also observe the operator properties of isometries mapping between these sets of exponentials. (Received September 20, 2009)

1056-47-1099 **Zhong Wang*** (kyczwang@zqu.edu.cn), Department of Mathematics, ZhaoQing university, GuangDong, PRC, ZhaoQing, GuangDong 526061, Peoples Rep of China, and **Hongyou WU**, Department of Mathematics, NIU, USA, IL 60115. *Spectral Analysis of Conjugate Self-Adjoint Operators.* Preliminary report.

This paper deals with a class of non-self-adjoint operators, i.e., conjugate self-adjoint operators. These operators are self-adjoint only up to a left factor of non-trivial conjugation operators. We deduce some analogue results about the spectrum for conjugate self-adjoint operators. Applying those results to Differential operators, we obtain a sufficiency and necessary conditions for the spectral discreteness of $J$-selfadjoint differential operator. (Received September 20, 2009)

1056-47-1142 **Dan D. Pascali*** (dp39@nyu.edu), Courant Institute, New York University, 251 Mercer Street, New York, NY 10012-1185. *Kinds of pseudomonotonocitiy in study of variational inequalities.*

The psudomonotonicity is the basic tool in proving the existence of solutions of varia-tional inequalities. There is a variety of algebraic and topological extensions related to generalized variational-like inequalities studied. A systematic arrangement of a part of these kinds of pseudomonotone set-valued maps is presented. A special attention is paid to nonlinear of monotone type with respect to two Banach spaces. (Received September 21, 2009)

1056-47-1165 **Katie Spurrier Quertermous*** (kgs5c@virginia.edu), University of Virginia, Department of Mathematics, P.O. Box 400137, Charlottesville, VA 22903-4137. *Fixed Point Composition $C^*$-algebras.*

Let $\varphi$ be an analytic self-map of the unit disk $\mathbb{D}$, and let $H^2(\mathbb{D})$ denote the Hardy space of the disk. We define the composition operator $C_\varphi$ on $H^2(\mathbb{D})$ by $C_\varphi f = f \circ \varphi$ for all $f \in H^2(\mathbb{D})$. In particular, we are interested in composition operators where $\varphi$ is a linear-fractional map that fixes a point $\zeta \in \partial\mathbb{D}$. In this talk, we will consider the structures of unital C*-algebras generated by collections of composition operators of this type. We will demonstrate how the structures of specific examples are related to the algebra of almost periodic functions on the real line and to a crossed product of a unital C*-algebra by an abelian group. (Received September 21, 2009)

1056-47-1375 **Meghna Mittal*** (mittal@math.uh.edu). *Function Theory on a Quantum Domain.*

In this talk, we will present an idea of quantizing the function theory on a family of complex domains. To give a brief description, whenever one replaces scalar variables by operator variables in a problem or definition, then this process is often referred as quantization. In some sense this process has been carried out for domains such as polydisk, ball, half planes and others by various authors. We approach these ideas via operator algebra methods to obtain existing and some "nice" new results. This talk is based on joint work with Vern Paulsen. (Received September 22, 2009)

1056-47-1399 **Shonia Giorgi*** (shonia@ohio.edu), Ohio University Lancaster, 1570 Granville Pike, Lancaster, OH 43130-1037. *Topology of invariant subspace lattice of shift operators in higher dimensions.*

Analytic description of invariant subspaces of the shift operator on a Hilbert space has been offered by Beurling's celebrated theorem and later generalised to shifts of arbitrary multiplicity. Using these results, following a study by R. Douglas and C. Pearcy description of path connected components of invariant subspace lattice for shift of multiplicity one has been given by R.Yang. In present paper we generalise result to arbitrary finite multiplicity. We show that there exists one to one correspondence between the invariant subspace lattice of a shift of arbitrary finite multiplicity and the space of inner functions.

The result is established first by constructing a family of inner functions in $L^2$ continuous manner. Among other, this requires selection of unique representative from a family of unitarily equivalent inner functions in a continuous manner. Finally, based on $L^2$ continuity, using techniques of reproducing kernel , sup norm continuity is proved.

The case of infinite multiplicity remains open to further research. (Received September 21, 2009)

1056-47-1417 **Waleed Khaled Al-Rawashdeh*** (wrawashdeh@yahoo.com), 1601 S. Washington Court Apartment # K-7, Mount Pleasant, MI 48858. *Weighted Composition Operators on Bergman Spaces in the Unit Ball.*

Let $\varphi$ be an analytic self-map of the unit ball $\mathbb{B}_n$ in $\mathbb{C}^n$ and let $\psi$ be an analytic function on $\mathbb{B}_n$. For $\alpha > -1$ and $p > 0$ the weighted Bergman space $A^p_\alpha(\mathbb{B}_n)$ consists of holomorphic functions f in $L^p(\mathbb{B}_n, dv_\alpha)$, that is,

$$A^p_\alpha = L^p(\mathbb{B}_n, dv_\alpha) \cap H(\mathbb{B}_n),$$

where $H(\mathbb{B}_n)$ denote the space of all holomorphic functions on $\mathbb{B}_n$, $dv_\alpha$ is the weighted Lebesgue measure given by

$$dv_\alpha(z) = (1 - |z|^2)^\alpha dv(z),$$

where $dv$ is the volume measure on $\mathbb{B}_n$.

We characterize the boundedness and compactness of the weighted composition operator $W_{\psi,\varphi} : f \mapsto \psi(f \circ \phi)$ from $A^p_\alpha$ into $A^q_\beta$, where $0 < p \leq q < \infty$ and $-1 \leq \alpha, \beta < \infty$, in terms of Carleson-type measures. The results use a certain integral transform that generalizes Berezin transform. (Received September 21, 2009)

1056-47-1451 **Genady Grabarnik*** (genadyg@hotmail.com), Scarsdale, NY 10583. *Quantum analog of Donoho-Stark Uncertainty Principle.*

The Uncertainty Principle of Donoho-Stark was estalished at 1989. We formulate and outline the proof of the Quantum variant of the Donoho-Stark Uncertainty Principle. (Received September 21, 2009)

1056-47-1754 **Julian Michael Buck*** (jbuck1@uoregon.edu), 2250 Patterson Street unit 194, Eugene, OR 97405. *Crossed Products by Automorphisms with the Tracial Quasi-Rokhlin Property.*

Crossed product constructions of C*-algebras associated to minimal topological dynamics have been an area of intense study in recent years. We introduce a new property for automorphisms of a C*-algebra, the tracial quasi-Rokhlin property, which is related to the various Rokhlin properties that have already appeared in the literature. We show that the crossed product C*-algebras by certain automorphisms with this property can have good structure properties. In particular, we consider the case where the automorphism is for the algebra C(X,A), the continuous functions from some compact metric space to a C*-algebra A. It is shown that under suitable conditions on the space X (what we have termed the dynamic comparison property), then an automorphism of C(X,A) which acts minimally on C(X) has the tracial quasi-Rokhlin property (in particular, this property applies to the well-known case of a minimal homeomorphism acting on C(X)). It will follow that the crossed products of C(X,A) by such automorphisms have good structure properties, which partly generalizes the situation for C(X). (Received September 22, 2009)

1056-47-1818 **P. P. B. Eggermont*** (eggermon@udel.edu), Food and Resource Economics, University of Delaware, Newark, DE 19717-1303, **V. N. LaRiccia**, Food and Resource Economics, University of Delaware, and **M. Z. Nashed**, Department of Mathematics, University of Central Florida. *On Weakly Bounded Noise in Ill-Posed Problems.*

We study compact operator equations with noisy data in Hilbert space. Instead of assuming that the error in the data converges strongly to 0, we only assume a type of weak convergence. Under the source conditions that are usually assumed in the presence of convex constraints, we derive optimal convergence rates for convexly constrained Phillips-Tikhonov regularization. We also discuss a version of the Lepskiĭ method for selecting the regularization parameter. (Received September 22, 2009)

1056-47-1853 **Mark Stankus*** (mstankus@calpoly.edu), 1 Grand Avenue, Department of Mathematics, San Luis Obispo, CA 93407. *n-symmetric Linear Transformations and von Neumann algebras.* Preliminary report.

Helton generalized the concept of self-adjoint map to that of an $n$-symmetric operator for natural numbers $n$. A bounded linear transformation $T$ of a complex Hilbert space is called $n$-symmetric if $\sum_{k=0}^{n}(-1)^k \begin{pmatrix} n \\ k \end{pmatrix} (T^*)^{n-k}\, T^k$ $= 0$. When classifying solutions to this equation, it suffices to consider solutions $T$ where the smallest von Neumann algebra containing $T$ is a factor. We show that if $T$ is an $n$-symmetric operator and the smallest von Neumann algebra containing $T$ is a factor, then the set of eigenvalues of $T^*$ is an interval in the real line. A combination of Rosenblum's Theorem, resolvent inequalities and the existence of maximal invariant subspaces is used. The techniques apply to a large class of hereditary roots. No knowledge of von Neumann algebras is required. (Received September 22, 2009)

1056-47-2107 **David Milan*** (dmilan@uttyler.edu), The University of Texas at Tyler, Department of Mathematics, 3900 University Boulevard, Tyler, TX 75799. *Computing the C*-algebra of an inverse semigroup with the Munn representation.*

We show that in many cases the Munn representation gives a useful description of the full C*-algebra of an inverse semigroup. Examples include the bicyclic monoid, free inverse semigroups, graph inverse semigroups and the inverse semigroups associated with quasi-lattice ordered groups. (Received September 23, 2009)

1056-47-2124 **Hutian Liang*** (hliang@uoregon.edu), 2250 Patterson St., Unit 39, Eugene, OR 97405. *Recursive Decomposition of a $C^*$-subalgebra of $C^*(R, X)$.* Preliminary report.

Crossed product of C*-algebras by locally compact groups have been studied widely. When the group is the the group of integers $Z$, and when the C*-algebras is the continuous functions on compact metric spaces $C(X)$, it is shown that, in some cases, the crossed product has tracial rank zero. The crossed product having tracial rank zero was shown, by Lin and Phillips, by looking at a subalgebra that has a recursive structure. In this presentation, we briefly introduce the crossed product of $C(X)$ by the reals $R$. We then will discuss how to find a subalgebra of the crossed product of $C(X)$ by $R$, analogous to the one in the integer case,that has an recursive structure. (Received September 23, 2009)

# 49 ► *Calculus of variations and optimal control; optimization*

1056-49-44 **Nasiruddin U Ahmed*** (ahmed@site.uottawa.ca), 800 King Edward Str., Ottawa, Ontario K1N6N5, Canada. *Operator Valued Measures as Feedback Control for Stochastic Systems on Hilbert Space.*

We consider a partially observed stochastic control problem with operator valued measures as controls.This is given by the following stochastic differential equation on the Hilbert space $X$ coupled with an algebraic equation representing noisy measurement process taking values from another Hilbert space $Y$ as follows:

$$dx = Axdt + B(dt)y(t-) + \sigma(t)dW(t), t \in I \equiv [0, T], x(0) = x_0 \tag{1}$$

$$y(t) = C(t)x(t) + \xi(t), t \in I. \tag{2}$$

The process $x$ is the state,$y$ is the observation and $W$ is a Brownian motion taking values from a Hilbert space $H$ and $\xi$ is an arbitrary second order $Y$ valued random processes. The operator $A$ is the generator of a $C_0$-semigroup of bounded linear operators on $X$, $B \in M_{cabv}(\Sigma, \mathcal{L}(Y, X))$ and $\sigma \in B_\infty(I, \mathcal{L}(H, X))$. The problem is to find a control policy $B \in \Gamma \subset M_{cabv}(\Sigma, \mathcal{L}(Y, X))$ that minimzes the functional

$$J(B) \equiv \int_I Tr(P(t))\ \lambda(dt) + \int_I |\bar{x}(t) - x_d(t)|_X^2 \nu(dt) + \Phi(B), \tag{3}$$

where $P(t)$,dependent on $B$, is the covariance operator taking values from the space of nuclear operators $\mathcal{L}_1(X)$ and $\lambda$ and $\nu$ are nonnegative measures. (Received July 09, 2009)

1056-49-173 **Josh Koslosky*** (Koslosky504@gmail.com), 120 Bartley rd., Pittsburgh, PA 15241, and **Stacey Levine** (levine.stacey@gmail.com), Dept. of Mathematics and Computer Science, Duquesne University, 440 College Hall, Pittsburgh, PA 15282. *Image Denoising Via Feature-Based Sparse and Redundant Dictionaries.* Preliminary report.

In recent years the computer vision community has demonstrated that sparse and redundant representations of image patches can be used to denoise images. These representations can be formed using dictionaries that are either fixed (e.g. Discrete Cosine Transform) or learned from the noisy data itself. Finding the best patch representation leads to a constrained optimization problem, which depending on its formulation can be nonconvex. Elad and Aharon propose such a model which learns the dictionary from the noisy data, which they solve using Orthogonal Matching Pursuit and K-SVD (a modification of the Singular Value Decomposition inspired by K-means). In this talk we propose a modification of their algorithm in which dictionaries can be tailored to denoise smooth regions, textured regions, and edges separately. In particular, we discuss several approaches for segmenting an image based on these different geometric properties, and how dictionaries tailored to these properties can improve both the image representation and denoising. (Received August 11, 2009)

1056-49-345 **Yingying Li*** (`yingyingli@math.ucla.com`), UCLA Mathematics Department, Box 951555, Los Angeles, CA 90095-1555, and **Stanley Osher** (`sjo@math.ucla.edu`), UCLA Mathematics Department, Box 951555, Los Angeles, CA 90095-1555. *Coordinate Descent for L1 Optimization.* Preliminary report.

As compressed sensing gains popularity, L1 optimization becomes more important than before since it preserves sparsity. However, the non-differentiability of the L1 norm brings difficulties in solving it. As a simple and traditional method for solving high dimensional optimization problems, coordinate decent can be applied to various applications with objectives involving an L1 term, for example, source identification and TV-based image denoising. (Received August 31, 2009)

1056-49-401 **Frank Morgan*** (`Frank.Morgan@williams.edu`), **Alexander Diaz**, **Nate Harman**, **Sean Howe** and **David Thompson**. *Generalized Steiner and Schwarz Symmetrization.*

We'll discuss a very general symmetrization theorem after Ros in arbitrary dimension and codimension, in products, warped products, and certain fiber bundles, including Steiner, Schwarz, and spherical symmetrization. (Received September 04, 2009)

1056-49-421 **Mau Nam Nguyen*** (`nguyenmn@utpa.edu`), Department of Mathematics, University of Texas-Pan American, 1201 W. University Dr., Edinburg, TX 78539. *Convex and Nonsmooth Analysis of Minimal Time Functions in Banach Spaces.*

We study generalized differential properties of the so-called *minimal time functions* associated with constant dynamics and arbitrary closed target sets. Functions of this type play a significant role in many aspects of optimization, control theory, and Hamilton-Jacobi partial differential equations. We pay the main attention to computing and estimating limiting subgradients of the minimal value functions and to deriving the corresponding relations for Fréchet subgradients in Banach spaces. We also derive new relations between subgradients minimal time functions and the corresponding convex subgradients of Minkowski functions. *(This talk is based on the joint work with Boris Mordukhovich)* (Received September 05, 2009)

1056-49-468 **Donald C. Sampson** (`dsampson@byu.net`), 136 Wymount Terrace, Provo, UT 84604, **Rebecca Dorff*** (`beccadorff@gmail.com`), 1850 N. University Ave. Apt. 310, Provo, UT 84604, and **James P Dilts** (`james.dilts@gmail.com`), 1000 E 450 N #11, Provo, UT 84604. *An Introduction to Metacalibration and its Application to Multiple Bubble Problems.*

Metacalibration is an exciting new method in geometric optimization authored by Gary Lawlor of Brigham Young University. It is a generalization of calibrated geometries. We present metacalibration theory and discuss its application to multiple bubble problems. These problems ask which figure minimizes boundary among all figures that separately enclose a given set of volumes. (Received September 08, 2009)

1056-49-469 **Moustapha N Pemy*** (`mpemy@towson.edu`), Mathematics Department, Towson University, 7800 York Road Room 316, Towson, MD 21204, and **Q Zhang** and **G Yin**. *Liquidation of a large block of stock with regime switching.*

Stock-selling rules are mainly concerned with liquidation of the security within a short period of time. In practice, this is feasible when a relatively smaller number of shares of a stock is involved. Selling a large position in a market place normally depresses the market if sold in a short period of time, which would result in poor filling prices. Comparing to the existing results in the literature, this work has two distinct features. First, the underlying stock price is modeled using a geometric Brownian motion formulation with regime switching in which the jump rate depends on the selling intensity. Secondly, we consider the liquidation strategy for selling a large block of stock by selling much smaller number of shares over a longer period of time. By using a fluid model, in which the number of shares is treated as fluid (continuous), we treat the selling rule problem where the corresponding liquidation is dictated by the rate of selling over time. Our objective is to maximize the expected overall return. Thus it may be formulated as a stochastic control problem with state constraints.

Method viscosity solution is used to characterize the dynamics governing the optimal reward function and the associated boundary conditions. Numerical examples are reported. (Received September 08, 2009)

1056-49-644 **Pengwen Chen*** (pengwen@math.uconn.edu), Department of Mathematics, 196 Auditorium Road, University of Connecticut, U-3009, storrs, CT 06269. *A novel kernel correlation model with correspondence estimation.*

We present a multiple linked iterative closest point method to estimate the correspondence and the rigid/nonrigid transformation between point-sets/shapes. The estimation task is carried out through maximizing a similarity function which is the product of square root functions and a kernel correlation. Intuitively this correspondence estimation framework is modified from the well-known mass transport problem. The local mean square error analysis and robustness analysis are provided to show its superior performance to the kernel correlation method. (Received September 15, 2009)

1056-49-673 **Joanna M. Papakonstantinou*** (jpapa@rice.edu), Rice University, Department of CAAM - MS 134, 6100 Main Street, Houston, TX 77005-1892. *Origin and Extensions of the Secant Method and Characterizations of the BFGS Secant Method.* Preliminary report.

Many people believe that the secant method arose from Newton's method using finite difference approximations to the derivative. In this talk, it is revealed that a special case of the secant method predated Newton's method by more than 3000 years. The evolution of secant methods is traced from 18th-century B.C. Babylonian clay tablets and the Egyptian Rhind Papyrus. As the secant method evolved, widespread confusion concerning the origins and the terminology used to refer to the secant method and the Regula Falsi method arose. To remove the existing confusion, the origins of these methods are determined and the terminology is clarified. Modifications to Newton's method that yield secant methods are discussed and the construction of several rank-two secant update classes are examined. The BFGS secant method is the preferred secant method for finite-dimensional unconstrained optimization. New characterizations of several secant update classes known to contain the BFGS update are presented. (Received September 15, 2009)

1056-49-695 **Andrea Bertozzi*** (bertozzi@math.ucla.edu), Department of Mathematics, UCLA, Los Angeles, CA 90095. *Variational methods for data fusion, segmentation, deblurring, and image inpainting.*

This talk is an overview of several recent methods. They include wavelet Ginzburg-Landau methods (diffuse interface) for inpainting and deconvolution, learning methods for deconvolution, variational wavelet pansharpening, and statistical searching methods for segementation of large datasets. (Received September 16, 2009)

1056-49-938 **Alexandru Tamasan*** (tamasan@math.ucf.edu), 4000 Central Florida Blvd., Orlando, FL 32816. *On a minimization problem for conductivity imaging.*

One of the newly developed hybrid methods to image the conductivity from interior knowledge of the magnitude of the current density field leads to the minimization problem argmin $\int_\Omega a|\nabla u|dx$, subject to $u = f$ on $\partial\Omega$. Some questions concerning existence, uniqueness and stability of the minimization problem in the space of functions of bounded variations are discussed. (Received September 18, 2009)

1056-49-1013 **Arthur D Szlam***, 715 broadway, New York, NY 10003, and **Xavier Bresson**. *Total Variation and Cheeger Ratio Cuts.* Preliminary report.

I will discuss a continuous relaxation of the Cheeger cut problem on a weighted graph (which is used in image segmentation), and show how the relaxation is actually equivalent to the original problem. Then I will introduce an algorithm which experimentally is very efficient at approximating the solution to this problem on some clustering benchmarks. I will also give a heuristic variant of the algorithm which is faster but often gives just as accurate clustering results. This is joint work with Xavier Bresson, inspired by recent papers of Buhler and Hein, and Goldstein and Osher, and by an older paper of Strang. (Received September 19, 2009)

1056-49-1049 **Elena Constantin*** (constane@pitt.edu), University of Pittsburgh at Johnstown, Department of Mathematics, Johnstown, PA 15904. *Higher Order Sufficient Conditions for Strict Minimality in Smooth Scalar Optimization.*

We are dealing with the following constrained minimization problem

$$F(\bar{x}) = \text{Local Min } F(x), \quad x \in G^{-1}(0) \;, \tag{P}$$

where $F : U \to \mathbb{R}$ is of class $C^p$ on the open set $U \subseteq \mathbb{R}^n$, $\bar{x} \in G^{-1}(0) = \{x \in \mathbb{R}^n; G(x) = 0\}$, $G : U \to \mathbb{R}^k$ is of class $C^m$ on $U$, and $p, k, n, m$ are positive integers.

Our goal is to present some higher order sufficient conditions for $\bar{x}$ to be a strict local minimizer to problem (P). Using our results we analyze some examples for which the second derivative test fails and one where the method of Lagrange multipliers can not be applied. (Received September 20, 2009)

1056-49-1104 **Cristina Popovici*** (cristina.popovici@ndsu.edu), North Dakota State University, Department of Mathematics, NDSU Dept. # 2750, P.O. Box 6050, Fargo, ND 58108-6050. *The asymptotic behavior of power-law functionals and applications.*

Γ-convergence results for power-law functionals are obtained in the framework of A-quasiconvexity. Applications to several models of polycrystal plasticity are described. Joint work with Marian Bocea (NDSU). (Received September 20, 2009)

1056-49-1194 **Jesus A. Pascal*** (pascal@math.lsu.edu). *On the Principle of Smooth Fit for Some Convex Optimal Control Problems.*

The purpose of this work is to show that the principle of smooth fit can even fail for convex optimal control problems. Using the Dynamic programming approach, we get the value function for a convex optimal control problem. The value function turns out to be a convex viscosity solution of the dynamic programming equation, not $\mathbb{C}^2$ along the free boundary, and hence not a classical solution of the above mentioned equation. (Received September 21, 2009)

1056-49-1335 **Yen-Nhi Nguyen-thi*** (nhi@math.wayne.edu), 1125 Faculty/Administration Building, 656 W Kirby, Detroit, MI 48202, **Boris Mordukhovich** (boris@math.wayne.edu), 1237 Faculty/Administration Building, 656 W Kirby, Detroit, MI 48202, and **Nam Mau Nguyen** (nguyenmn@utpa.edu), MAGC 3.808, 1201 West University Drive, Edinburg, TX 78539. *Coderivatives in Parametric Optimization in Asplund Spaces.*

In this talk, we first develop some calculus rules for second-order partial subdifferentials of extended real-valued functions in the framework of Asplund spaces. We then apply these rules in the study of a family of parameterized optimization problems in which both cost function and constraint function are nonsmooth extended real-valued, and conduct local sensitivity analysis for the stationary point and stationary point-multiplier multifunctions. (Received September 21, 2009)

1056-49-1514 **Peter Elbau*** (peter.elbau@oeaw.ac.at), Johann Radon Institute for Computational, and Applied Mathematics, Altenbergerstrasse 69, A-4040 Linz, Austria. *Sequential Lower Semi-Continuity of Non-Local Functionals.*

From classical results of the calculus of variations, we know that the sequential lower semi-continuity of a functional $\mathcal{J}$ on $L^p(X)$ of the form $\mathcal{J}(u) = \int_X f(x, u(x)) d\mu(x)$ can be directly expressed in terms of the function $f$. If we were e.g. looking for sequential lower semi-continuity with respect to the weak topology on $L^p(X)$, then $f$ had to be convex in the second argument.

The aim of this talk will be to analyse non-local functionals $\mathcal{J}$ on $L^p(X)$ of the form

$$\mathcal{J}(u) = \int_X \int_X f(x, y, u(x), u(y)) d\mu(x) d\mu(y)$$

and see how far these classical results can be generalised. We will mainly focus on the conditions for the functional to be sequentially lower semi-continuous with respect to the weak topology on $L^p(X)$, which will turn out to be that the function $f$ is (up to equivalence) separately convex in the third and fourth argument. (Received September 22, 2009)

1056-49-1645 **Siddartha P. Chakrabarty**, Department of Mathematics, Indian Institute of Technology Guwahati, Guwahati, Assam 781039, India, and **Hem R Joshi*** (joshi@xavier.edu), 3800 Victory Parkway, Department of Mathematics and CS, Cincinnati, OH 45207-4441. *Optimal Control and its Application to Hepatitis C Treatment.*

We use optimal control techniques to determine an optimal treatment strategy for hepatitis C. We formulate a mathematical model using a system of ordinary differential equations, which describes the interaction of target cells (hepatocytes), infected cells, infectious virions, non-infectious virions and the two drugs, namely, interferon and ribavirin. We solve an optimal control problem with an objective functional that minimizes the viral load as well as the side effects of treatment. We will conclude with some numerical simulations. (Received September 22, 2009)

1056-49-1648 **Tom Goldstein***, UCLA Department of Mathematics, Box 951555, Los Angeles, CA 90095, and **Xavier Bresson** and **Stanley Osher**. *Global Minimization of Markov Random Fields with Applications to Optical Flow.*

Many problems in image processing can be posed as non-convex minimization problems. For certain classes of non-convex problems involving scalar-valued functions, it is possible to recast the problem in a convex form using a "functional lifting" technique. In this paper, we present a variational functional lifting technique that can be viewed as a generalization of previous works by Pock et. al and Ishikawa. We then generalize this technique to the case of minimization over vector-valued problems, and discuss a condition which allows us to determine when the solution to the convex problem corresponds to a global minimizer. This generalization allows functional lifting to be applied to a wider range of problems then previously considered. Finally, we present a numerical method for solving the convexified problems, and apply the technique to find global minimizers for optical flow image registration. (Received September 22, 2009)

1056-49-1654 **Adam Attarian*** (arattari@unity.ncsu.edu), Box 8205, Department of Mathematics, Raleigh, NC 27695-8205, **Tallis J William** (wjtallis@ncsu.edu), Box 8205, Department of Mathematics, Raleigh, NC 27695-8205, **Hien T Tran** (tran@math.ncsu.edu), Box 8205, Department of Mathematics, Raleigh, NC 27695-8205, and **Lawrence Ives** (rli@calcreek.com), 690 Port Drive, San Mateo, CA 94404-1010. *Application of Nonlinear Optimization in the Design of a Doubly Convergent Multiple-Beam Electron Gun.*

In this work we design a new class of electron devices using nonlinear optimization techniques. Through the use of parametric 3D modeling and simulation software, we perform optimizations on physical device geometry while realizing several engineering design constraints. With the application of an optimization methodology, the repetitive task of parameter variation is automated, permitting a new generation of asymmetric electron devices to be designed. Specifically, we consider a doubly convergent electron beam where the beam converges both about the local gun axis as well as the larger device axis. Goal functions and optimization methodology will be discussed in detail. (Received September 22, 2009)

1056-49-1675 **Richard C Barnard*** (rbarnard@math.lsu.edu), 303 Lockett Hall, Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, and **Peter R Wolenski**. *The Minimal Time Problem On Stratified Domains.*

We consider optimal control problems with stratified dynamics that are discontinuous across prescribed submanifolds. We show that the minimal time function is a proximal solution to the Hamilton-Jacobi equation suitably redefined to account for the discontinuities. (Received September 22, 2009)

1056-49-1684 **M. Zuhair Nashed***, University of Central Florida, 4000 Central Florida Blvd., Orlando, FL 32816, and **Alexandru Tamasan**, University of Central Florida. *Local stability in a minimization problem for conductivity imaging.*

We consider the problem of minimization of the functional $\int_\Omega a|\nabla u|dx$ over functions of bounded variation with prescribed trace $f$ at the boundary. The stability of the minimum value of the functional with respect to the coefficient $a \in L^2(\Omega)$ is established in the vecinity of a coefficient of the form $a = \sigma|\nabla u|$, where $u$ is $\sigma$- harmonic with trace $f$ at the boundary. This problem occurs in conductivity imaging when knowledge of the magnitude of the current density field inside a body is available. (Received September 22, 2009)

1056-49-1690 **Michael C. Barg*** (mbarg@niagara.edu), Mathematics Department, 339 Dunleavy Hall, Niagara University, Niagara University, NY 14109, and **Jieun Lee** and **Frank Baginski**. *Analysis of Tendon-Reinforced Piecewise-Isotropic Pressurized Membranes.*

A mathematical model for a tendon-reinforced piecewise-isotropic thin inflated wrinkled membrane subjected to a position dependent hydrostatic pressure load is presented. Such a model can be used to represent a large scientific balloon, like one of those currently flown by NASA, or some other inflatable structure. The total energy of the system is assumed to consist of a position dependent hydrostatic pressure, relaxed film strain, and film and tendon weight. Energy minimizing shapes can be found as relative minimizers to a constrained optimization problem via direct methods in the calculus of variations. (Received September 22, 2009)

1056-49-1702 **David C Szurley*** (dszurley@fmarion.edu), 405 N Ebenezer Rd., Florence, SC 29501. *Sensitivity-Based Optimization Applied to Equations Modeling Film Casting.*

There are many techniques to solve optimization problems. Sensitivity-based optimization methods determine the effect a change in the control variables has on the state variables. We may apply sensitivity-based optimization to real-world physical processes modeled by partial differential equations. In this setting, we would like to optimize an aspect of the process subject to the modeling equations.

The abstract setting for sensitivity-based optimization will be described, and its advantages and disadvantages will be discussed. We will then consider a system of nonlinear differential equations that model film casting. The sensitivity system for these equations will be derived, and a solution to a physical problem will be presented. (Received September 22, 2009)

1056-49-1717 **Eitan Tadmor** (tadmor@cscamm.umd.edu), The University of Maryland, CSCAMM, 4146 CSIC Building #406, Paint Branch Drive, College Park, MD 20742, and **Prashant Athavale*** (prashant@math.ucla.edu), Department of Mathematics, University of California, 520 Portola Plaza, Los Angeles, CA 90095. *Novel Integro-differential equations in image processing and its applications.*

We show that the hierarchical multiscale image representation of Tadmor, Nezzar and Vese, [2004], gives rise to a novel integro-differential equation (IDE) for a multiscale image representation. To this end, one *integrates* in inverse scale space a succession of refined, recursive 'slices' of the image, which are balanced by a typical curvature term at the finer scale. The importance of the IDE lies in the fact that even though its motivation comes from a variational problem, we can manipulate the IDE suitable to our image processing needs. We propose different forms of the IDE with filtering, tangential smoothing, and deblurring. (Received September 22, 2009)

1056-49-1724 **Ana-Maria Croicu*** (acroicu@kennesaw.edu), 1000 Chastain Rd., Kennesaw, GA 30144. *A Non-Stochastic Talk on Stochastic Optimization / Control.*

Problems of optimality / control under uncertainty or stochastic optimization / control problems occur frequently in real world situations, in science, engineering, technology, etc. Generally, these problems are governed by models which have probabilistic parameters, nondeterministic initial conditions, uncertain input situations, or by models based on incomplete knowledge. The aim of the talk is to make the audience aware of possible ways to approach real-life stochastic optimization / control problems. (Received September 22, 2009)

1056-49-1850 **Kyle Fey*** (s-kfey2@math.unl.edu), University of Nebraska - Lincoln, Department of Mathematics, 203 Avery Hall 880130, Lincoln, NE 68588-0130, and **Mikil Foss**. *Morrey Regularity for Asymptotically Convex Variational Problems with $(p, q)$ Growth.*

I will present global Morrey regularity results for minimizers of functionals with the general form

$$u \mapsto \int_\Omega f(x, \nabla u(x))\,\mathrm{d}x.$$

The function $F \mapsto f(x, F)$ is assumed to behave like a rotationally symmetric convex function with $(p, q)$ growth whenever $|F|$ is sufficiently large. The regularity results are valid up to the boundary provided that the boundary data is sufficiently smooth. (Received September 22, 2009)

1056-49-1967 **Jung-Ha An*** (jan@csustan.edu), One University Circle, Turlock, CA 95382, and **Yunmei Chen**. *A MODIFIED PIECEWISE CONSTANT MUMFORD-SHAH MODEL BASED SIMULTANEOUS IMAGE SEGMENTATION AND REGISTRATION.* Preliminary report.

A new variational region based model for a simultaneous image segmentation and registration is proposed. The purpose of the model is to segment and register novel images simultaneously using a modified piecewise constant Mumford-Shah technique and region intensity values. The segmentation is obtained by minimizing a modified piecewise constant Mumford- Shah model. A registration is assisted by the segmentation information and region intensity values. The numerical experiments of the proposed model are tested against simulated normal noisy human-brain magnetic resonance (MR) images. The preliminary experimental results show the effectiveness of the model in detecting the boundaries of the given objects and registering novel images simultaneously. (Received September 22, 2009)

1056-49-2102 **Eldad Haber*** (haber@math.ubc.ca), Dept of Mathematics, UBC, Vancouver, BC V6T 1Z4, Canada, and **Lior Horesh** and **Luis Tenorio**. *Design in inverse problems.*

While much attention has been given for the solution of inverse problems, very little attention has been given to the topic of design in inverse problems. Design naturally arises when different experiments are considered or when one has an option to choose different regularization operators.

In this talk we present a systematic framework for design in inverse problems. We show that it leads to stochastic optimization problems. We further suggest effective algorithms for the solution of the problem. (Received September 23, 2009)

1056-49-2145 **Mila Nikolova*** (nikolova@cmla.ens-cachanfr). *Reconstruction of Piecewise Constant Images Using Nonsmooth Noncovex Minimization.*
We discuss consider the restoration of piecewise constant images where the number of the regions and their values are not fixed in advance, using minimization methods for nonsmooth nonconvex functionals. (Received September 23, 2009)

1056-49-2148 **Lior Horesh*** (lhoresh@us.ibm.com), IBM T J Watson Research Center, 1101 Kitchawan Rd, suite 32-243, Yorktown Heights, NY 10598, **Eldad Haber** (haber@math.ubc.ca), Department of Mathematics, University of British Colombia, Vancouver, BC V6T 1Z4, Canada, and **Luis Tenorio** (ltenorio@mines.edu), Mathematical and Computer Sciences, Colorado School of Mines, Chauvenet 232, Golden, CO 80401. *Inversion - Taking one step backwards.*
As part of our efforts to harness mathematic to make our planet smarter, and in particular more instrumented, one ought to consider optimal setting of measurement sensors and even more generally any other controllable parameters of the apparatus and process (e.g. regularization). While design for well-posed problems has been extensively studied in past years, very little attention has been devoted to its ill-posed counterpart. This stands in contrast to the fact that we challenge more and more of real-life problems are of such nature. In this talk we shall describe some of the intrinsic difficulties associated with ill-posed inverse problems, lay out a coherent mathematical formulation to address them and finally demonstrate the importance of design for both medical and geophysical imaging problems. (Received September 23, 2009)

# 51 ► Geometry

1056-51-42 **Brian White***, Stanford University, Department of Mathematics, Stanford, CA 94305-2060. *Evolving Curves and Surfaces.*
Perleman used Hamilton's Ricci flow to prove the Poincare conjecture. In this talk, I will discuss other interesting geometric flows that have many features in common with the Ricci flow, but that are more intuitive and easier to visualize.. (Received July 08, 2009)

1056-51-116 **Steven Schlicker*** (schlicks@gvsu.edu), Department of Mathematics, Grand Valley State University, 1 Campus Drive, Allendale, MI 49401, and **Katrina Honigs**, University of California, Berkeley. *Edge Coverings of Bipartite Graphs and the Geometry of the Hausdorff Metric.*
An edge covering of a graph $G = \{V, E\}$ is a subset $E'$ of $E$ so that each vertex in $V$ has at least one incident edge in $E'$. Edge coverings of bipartite graphs have applications to the strange and non-intuitive geometry that the Hausdorff metric imposes on the space $\mathcal{H}(\mathbb{R}^n)$ of all non-empty compact subsets of $\mathbb{R}^n$. In particular, edge coverings of bipartite graphs provide insight into the behavior of configurations in this geometry. A configuration is a pair $[A, B]$ of elements in $\mathcal{H}(\mathbb{R}^n)$ for which there can be a finite number, denoted $\#([A, B])$, of elements in $\mathcal{H}(\mathbb{R}^n)$ at each location on the line segment between $A$ and $B$. Configurations exist so that $\#([A, B]) = k$ for infinitely many different values of $k$, and for $1 \leq k \leq 36$ with the exception of $k = 19$. Surprisingly, there are no configurations $[A, B]$ for which $\#([A, B]) = 19$. Edge coverings of bipartite graphs can be used to prove this result as well as extend it to show that there are no configurations $[A, B]$ for which $\#([A, B]) = 37$. (Received July 28, 2009)

1056-51-275 **Jared R. Bunn*** (bunn@math.utk.edu), 715 Chestnut Oak Drive, Knoxville, TN 37909. *Generalizations to Coarse Geometry.* Preliminary report.
We discuss generalizations of properties of discrete metric spaces associated with coarse geometry. Most notably, bounded geometry and Property A. In particular, we are interested in generalizations to non-discrete spaces and coarse spaces. Examples include Buyalo and Schroeder's definition of bounded geometry for metric spaces and John Roe's definition of bounded geometry for coarse spaces. (Received August 24, 2009)

1056-51-284 **Paul W Lewis*** (lewis@math.utk.edu). *Lagrangian representations of the (p, q, r)-triangle group.* Preliminary report.
We consider representations of the (p,q,r) – triangle group by considering embeddings of the reflection triangle group into the full group of isometries of the complex hyperbolic plane. Considering representations where generators of the reflection triangle group are mapped to reflections in Lagrangian planes, we investigate these representations using the configuration of R-circles in the boundary of the complex hyperbolic plane. (Received August 25, 2009)

1056-51-323 **Hurlee Gonchigdanzan*** (hurlee@uwsp.edu), Department of Mathematical Sciences, University of Wisconsin, Stevens Point, WI 54482. *How much does a Hamiltonian cycle weigh?* Preliminary report.

A Hamiltonian cycle in a graph is a path in the graph which visits each vertex exactly once and returns to the starting vertex. Let $K_n$ be a weighted complete graph with $n$ vertices. The weight of an edge is defined as the square of the distance between two end points of the edge. The weight of a path is the sum of the weights of all edges in the path. We establish a precise estimate for the weight of a Hamiltonian cycle in $K_4$ and $K_5$. (Received August 31, 2009)

1056-51-574 **Robert D. Knight*** (knightr@ohio.edu), Ohio University-Chillicothe, 101 University Dr, Chillicothe, OH 45601. *Relationships between Bundle Forms in Laguerre Planes.*

A Laguerre plane is a near linear space with two types of lines: null and positive. The set of lines is partitioned into parallel classes and Playfair's axiom is satisfied. A null line and a positive line cannot be parallel. The geometry also contains special affine planes called singular planes. Each singular plane contains null lines from exactly one parallel class and positive lines from at least two parallel classes. Each null line lies in exactly one singular plane and each positive line is contained in exactly two singular planes. In addition, if a null line is not in the parallel class of any line within a singular plane, then it intersects that plane. In a projective space the Veblin-Young axiom (Pasch's Lemma) allows us to construct a projective plane containing any two given intersecting lines. In a Laguerre plane this construction is complicated by three factors: parallelism, the two types of lines, and the fact that a pair of points do not necessarily lie on a line. The first two of these complications lead to 26 variants of the Veblin-Young axiom, called "bundle forms". Which bundle forms hold fundamentally effects the structure of a Laguerre plane. In this paper we prove several interrelationships between these bundle forms. (Received September 13, 2009)

1056-51-634 **Prim Plansangkate***, Centre de recherches mathématiques, Université de Montréal, P.O. Box 6128, Centre-ville Station, Montréal (Québec), H3C 3J7, Canada. *Affine sphere equation, Hitchin system and Painleve III.*

We give a gauge invariant characterisation of the symmetry reduction from the anti-self-dual Yang-Mills system on $R^4$ with gauge group $SU(2,1)$ to the affine sphere equation

$$\psi_{z\bar{z}} + \frac{1}{2}e^{\psi} + |U|^2 e^{-2\psi} = 0, \quad U_{\bar{z}} = 0,$$

which arises in the context of Strominger-Yau-Zaslow conjecture in mirror symmetry. The radially symmetric solutions of the affine sphere equation are characterised by solutions of the Painleve III equation with special values of parameters. (Received September 15, 2009)

1056-51-696 **Kazuki Hasebe*** (hasebe@dg.takuma-ct.ac.jp), Takuma-cho, Koda 551, Mitoyo, Kagawa 769-1192. *Non-compact Hopf Maps, Quantum Hall Effect, and Twistor Theory.* Preliminary report.

We discuss close relations between quantum Hall effect and twistor theory. For this purpose, we first introduce a non-compact version of the Hopf maps based on the split-algebras. With use of the split-quaternionic Hopf map, we construct quantum Hall effect on a 4D ultra-hyperboloid. In the lowest Landau level, the symmetry is enhanced from SO(3, 2) to the SU(2, 2) conformal symmetry of the twistor. We point out that the quantum Hall effect naturally realizes the philosophy of twistor theory, such as incidence relation, more fundamental space than space-time. In particular, the emergence mechanism of fuzzy space-time will be discussed somehow in detail. (Received September 22, 2009)

1056-51-863 **Thomas J Osler*** (osler@rowan.edu), Mathematics Department, Rowan Univeristy, Glassboro, NJ 08028. *Another look at Euler's parallel oblique-angled diameters.*

In the paper E83, (On some properties shared between conic sections and infinitely many other curves), Euler was examining properties of the conic sections that could be shared by more general curves. Most of the paper is concerned with "oblique-angle diameters", a concept that seems to have been familiar to his readers in the eighteenth century, but has been ignored today.

Definition: Given a curve, and the line (diameter) ET , with an associated number m. Then the line ET is called an oblique-angled diameter for this curve, if every chord with slope m is bisected by the diameter ET. If the diameter and curve intersect at T where a well defined tangent line exists, then the slope of this tangent line is the number m.

This paper contains six main theorems and one construction. When the same theorems appear in E83, our proofs of these theorems differ widely from those given by Euler. Two of our theorems and the construction are not found in Euler's paper and may be new. Among the proofs is the fact that if a curve has two parallel diameters, then it has infinitely many parallel diameters, all equally spaced. We also prove that the parabola is the only curve in which every line parallel to the axis is an oblique-angled diameter. (Received September 18, 2009)

1056-51-1041 **Benjamin Schmidt*** (schmidt@math.msu.edu), A207 Wells Hall, East Lansing, MI 48824, and **Keith Burns**. *On the singularities of the exponential map.*

Let p be a point in a complete Riemannian manifold M and let $\exp_p : T_pM \to M$ denote the exponential map. Between 1932 and 1965, papers of Littauer-Morse, Savage, and Warner established that a nonzero vector $v \in T_pM$ is a singular point of $\exp_p$ if and only if $\exp_p$ fails to be locally injective at the vector $v$. In recent joint work with Keith Burns, we show that local injectivity fails in radial directions. I'll discuss this work and an application that characterizes constant curvature projective spaces. (Received September 20, 2009)

1056-51-1119 **Oscar E Vega*** (ovega@csufresno.edu), 5245 North Backer Avenue M/S PB 108, Fresno, CA 93740, and **Esteban M Diaz**. *Translation planes admitting a linear Abelian group of order* $(q+1)^2$.

Under the conditions of $q$ being an odd prime power and $q^2 - 1$ having a $p$-primitive divisor, we have shown that translation planes of order $q^2$ with kernel containing $GF(q)$ that admit a linear Abelian group of order $(q+1)^2$ containing at most three kernel homologies must be associated to a flock of a quadratic cone. (Received September 21, 2009)

1056-51-1305 **Ricardo Enrique Rojas*** (ricardo.rojas@northern.edu), 1200 South Jay Street (#714), Aberdeen, SD 57401. *A Characterization Of The Finite Affine Translation Planes Of Odd Order.* Preliminary report.

We define a condition for finite affine planes known as the Hexagonal Condition. We then prove that a finite affine plane satisfies the Hexagonal Condition if and only if it is a translation plane of odd order. (Received September 21, 2009)

1056-51-1342 **J. Elisenda Grigsby*** (grigsbyj@bc.edu), 301 Carney Hall, Boston College, Chestnut Hill, MA 02467, and **Stephan M. Wehrli**. *On Khovanov homology and Heegaard Floer homology.*

I will discuss an algebraic relationship between the Khovanov homology of certain tangles in product sutured manifolds and the Heegaard Floer homology of their sutured double-branched covers. This relationship implies that Khovanov's categorification of the reduced n-colored Jones polynomial detects the unknot whenever n > 1.

Furthermore, certain TQFT operations (e.g., cutting and stacking) on the tangles correspond naturally to geometric operations (e.g., generalized plumbing) on the sutured double-branched covers, and the algebraic connection between Khovanov and Heegaard-Floer homology behaves naturally with respect to these operations.

This is joint work with Stephan Wehrli. (Received September 21, 2009)

1056-51-1425 **Moon Duchin*** (mduchin@umich.edu), **Christopher J Leininger** and **Kasra Rafi**. *Length-spectral rigidity for flat metrics.*

Fix a surface $S$ with a negatively curved metric and consider the marked length spectrum of all closed curves. These length data uniquely determine the metric among all negatively curved metrics on $S$, by a theorem of Otal. For metrics of constant negative curvature, the situation is much more rigid: it suffices to record the lengths of simple closed curves (and in fact, just $6g-5$ curves will do for the surface of genus $g$). In joint work with Leininger and Rafi, we consider the rigidity of the length spectrum for singular flat metrics (semi-translation structures) on $S$, and give a complete solution describing which simple curve sets are rigid. (Received September 21, 2009)

# 52 ▶ *Convex and discrete geometry*

1056-52-51 **Adnan Sljoka** (adnanslj@yorku.ca), Mathematics and Statistics, 4700 Keele Street, York University, Toronto, Ontario M3J 1P3, Canada, and **Walter Whiteley*** (whiteley@mathstat.yorku.ca), Mathematics and Statistics, York University, 4700 Keele Street, Toronto, Ontario M3J 1P3, Canada. *Predicting Flexibility and Motions of Proteins Using Rigidity.*

Given the 3-D structure of a biomolecule such as a protein, understanding how it functions depends in critical ways on predicting which parts are rigid, and which are flexible. Some biological data (NMR ensembles, multiple configurations, HD exchange) can provide experimental insight. We can model the molecule like an engineered structure of fixed units (atoms with their bond angles as rigid units, bonds as potential hinges) plus biochemical constraints coming from the geometry (hydrogen bonds, hydrophobic interactions). This generates a 'molecular graph' in the theory of combinatorial rigidity. Drawing on graph-theoretic algorithmic methods for bar-body frameworks (the $6|V|-6$ pebble game), as well as the 25 year old molecular conjecture, a basic algorithm on the molecular graph makes flexibility/rigidity predictions for the molecular structure. The predictive algorithm is embedded in an online FIRST server at flexweb.asu.edu, along with an extension FRODA to model the initial motions of the molecule.

Our recent work has extended this basic model to predict hinge motions of proteins, as well as some preliminary predictions for 'allostery' – where binding on one portion of a large molecule changes the shape or binding at a distance 'active site' of the molecule. (Received July 13, 2009)

1056-52-595 **Avraham Bourla*** (bourla@math.uconn.edu), 44 Tolland Ave. #37, Stafford Springs, CT 06076. *Geometric properties of continued fractions.*

The regular continued fraction expansion of a real number relates to the cutting sequence of a geodesic in the hyperbolic plane through the Farey tessellation, having the modular group acting as a group of transformations.

In this talk, we will illustrate this relationship in the spirit of C. Series' papers. Then, we will briefly discuss a type of continued fractions that arises when we differ from the classical case. (Received September 14, 2009)

1056-52-886 **Michele Vergne*** (vergne@math.jussieu.fr), 9 rue de Navarre, 75005 Paris, France. *Jump formulae for Multiple Bernoulli polynomials and Verlinde sums.* Preliminary report.

Motivated by Witten and Verlinde formulae for the volume and Riemann Roch number of some moduli space, A. Szenes studied multiple Bernoulli series and Verlinde sums, associated to a vector space $V$, a lattice $\Lambda$ in $V$ and a sequence $\Phi$ of elements of $\Lambda$. Such a Bernoulli series defines a periodic and locally polynomial function on $V$ and satisfy a system of differential equations, associated to deletion and contraction in the system $\Phi$. In a work in common with Arzu Boysal, we give formulae for the jumps across singular hyperplanes.

There is an analogous theory in the discrete case, where differential equations are replaced by difference equations. Solutions are locally quasi-polynomial functions, and the domains of quasi polynomiality are related to the zonotope constructed on $\Phi$. (Received September 18, 2009)

1056-52-1416 **Sarah Fletcher**, **Christopher S. Hardin** and **Francis Edward Su*** (su@math.hmc.edu), Department of Mathematics, Harvey Mudd College, 301 Platt Blvd., Claremont, CA 91711. *The agreement number of tree societies.*

We consider a $(k,m)$-*agreeable tree society*, which is a tree together with a collection of subtrees that have the following intersection property: among every $m$ subtrees there are $k$ subtrees that contain a common point. This is a generalization of a model of Berg et.al., who considered a $(k,m)$-agreeable *linear* society, motivated by a voting analogy and a connection to Helly's theorem. The *agreement number* of a society is the size of the largest mutual intersection. In this paper, we show that the bound for the agreement number of linear societies also holds for tree societies; in particular, the agreement number is at least $(k-1)/(m-1)$ times the number of sets in the collection. We also establish a class of examples in which the bound can be improved using a new reduction technique. (Received September 21, 2009)

# 53 ► *Differential geometry*

1056-53-31 **Robert L Bryant*** (bryant@msri.org), 17 Gauss Way, Berkeley, CA 94720-5070. *Invariants of projective structures on surfaces and some applications.*

The geometry of projective structures on surfaces was studied classically by many people, with important contributions having been made by S. Lie, R. Liouville, A. Tresse, and J. Levine, among others. In particular, Liouville, in 1887, was the first to write down tensorial invariants and apply them to problems, such as characterizing projective structures that come from metrics. Cartan showed how to attach a projective connection to a projective structure and discussed how to generate differential invariants, though he did not find a method to generate all of the differential scalar invariants. In fact, a considerable amount of parabolic invariant theory machinery is still needed to do this.

In this talk, I will review the basics of projective structures on surfaces, including Liouville's tensor and Cartan's projective connection. I will discuss Liouville's method of generating higher order differential invariants through projective differential operators and interpret this in the context of Cartan's approach. Finally, I will apply this machinery to the classical problem, recently solved by Dujnaski, Eastwood, and myself, of characterizing those projective structures that arise from non-degenerate quadratic forms on surfaces. (Received June 23, 2009)

1056-53-82 **Julia C Bennett*** (juliacbennett@gmail.com), 6449 Regent St., Oakland, CA 94618, **David V Cochran** (cochrandv@vcu.edu), 2705A Floyd Ave., Richmond, VA 20135, and **Kaitlin Woskoff** (woskoffk@hartwick.edu), 68 Granada Circle, Mount Sinai, NY 11766. *Symplectic Volumes and Ribbon Graphs.*

Volume is a concept which, usually in our minds, exists only in three dimensions. Pardoning the said connotation, it makes perfect sense to talk about the volume of objects of any dimension. We investigate the calculation of the volume of ribbon graph complexes: structures which are characterised by dimension.

There is a well-defined (though tiresome) approach to these calculations which we use to launch our invesigation, enabling us to approach the problem differently. As it turns out, ribbon graph complexes have many nice properties which allow us to use methods from symplectic geometry to generalize the volume calculations – relating the volume of a complex of some dimension to that of a complex of lower dimension – allowing us to recursively calculate the volume of complexes of arbitrary dimension. (Received July 23, 2009)

1056-53-99 **Alexander Diaz*** (alexander.diaz1@upr.edu), Urb. Estancias del Bosque, 363 Calle Nogales G7, Cidra, PR 00739, and **Nate Harman**, **Sean Howe** and **David Thompson**. *The Isoperimetric Problem in Sectors with Disk Density.*

A manifold with density is a manifold with a positive function weighting both perimeter and area. I consider the isoperimetric problem in planar sectors with density $a$ inside the unit disk and density 1 outside. There are ten types of solutions, depending on $a$, the sector angle, and the prescribed area. Another interesting feature of this problem is that it deals with a noncontinuous density.
(Received July 27, 2009)

1056-53-100 **Alexander Diaz**, **Nate Harman** and **Sean P Howe*** (seanpkh@gmail.com), 521 E 1st st., Moscow, ID 83843, and **David Thompson**. *Isoperimetric Regions in Planar Sectors with Density $r^p$.*

A manifold with density is a manifold with a positive function weighting both volume and perimeter. They have received increasing attention in recent years, most notably appearing in Perelman's proof of the Poincare conjecture. Building on the work of Dahlberg et al. in the plane, we consider the isoperimetric problem in planar sectors with radial density $r^p$, a problem of particular interest because of its relation to the $L^p$ norm. We show that for $p \in (-\infty, 0)$ isoperimetric curves are circular arcs about the origin and for $p \in [-2, 0)$ isoperimetric curves do not exist. For $p > 0$, we show that for sectors of small angle circular arcs about the origin are isoperimetric, for sectors of large angle circular arcs through the origin are isoperimetric, and for a transition period in between isoperimetric curves are members of a family of unduloids. We provide bounds on the angles of the transition in terms of $p$ and conjecture on the exact values. The conjecture is supported by theoretical results and numerical evidence. (Received July 27, 2009)

1056-53-101 **Alexander Diaz** and **Nathan Harman*** (nateharman1234@yahoo.com), 1203 S. Fernandez Ave., Arlington Heights, IL 60005, and **Sean Howe** and **David Thompson**. *Manifolds with Density as Quotients of Riemannian Manifolds.*

A manifold with density is a Riemannian manifold equipped with a positive density function that weights both volume and hypersurface area. One place these come up naturally is as quotients of Riemannian manifolds by a subgroup of their isometry group. First, we use this interpretation to solve the isoperimetric problem in certain manifolds with density by looking at the problem in a suitable Riemannian manifold modulo symmetry. Second, we discuss conditions under which solving the isoperimetric problem in a Riemannian manifold can be reduced to solving it in a manifold with density of lower dimension. (Received July 27, 2009)

1056-53-187 **Arvind S. Rao*** (arao@math.uiowa.edu), Department of Mathematics, 14 Maclean Hall, Iowa City, IA 52242. *Weak Solutions to a Degenerate Monge-Ampère Type Equation on Kähler Surfaces.*

In the context of moment maps and diffeomorphisms of Kähler manifolds, Donaldson introduced a fully nonlinear Monge-Ampère type equation. Among the conjectures he made about this equation is that the existence of solutions is equivalent to a positivity condition on the initial data. Weinkove later affirmed Donaldson's conjecture using a gradient flow for the equation in the space of Kähler potentials of the initial data. The case when the initial data is merely semipositive and the domain is a closed Kähler surface is the topic of my thesis and this talk. I will show how regularity techniques for degenerate Monge-Ampère equations, specifically those coming from pluripotential theory, are used to prove the existence of a unique, bounded, weak solution. A Nakai criterion, due to Lamari and Buchdahl, guarantees that the solution is smooth away from some curves of negative self-intersection. (Received August 13, 2009)

1056-53-366 **Jeffrey L Jauregui*** (jeff@math.duke.edu), Mathematics Department, Duke University, Box 90320, Durham, NC 27708. *Optimization problems within a harmonic conformal class.*

I will introduce four functions that arise from certain geometric optimization problems on the harmonic conformal class of an asymptotically flat manifold. These functions are natural, in that they are independent of the choice of metric in the class. Two of them turn out to be trivial, but the other two are more interesting and are pertinent to a generalization of the Riemannian Penrose Inequality. (Received September 02, 2009)

1056-53-375 **Jörg Frauendiener*** (joergf@maths.otago.ac.nz), Dept. of Mathematics and Statistics, PO Box 56, Dunedin, 9010, New Zealand. *Local twistors and the conformal field equations.*

The conformal field equations of General Relativity are a conformally invariant generalisation of Einstein's vacuum field equations. In this presentation we discuss the origin of the conformal field equations and their main properties. Furthermore, we establish a link between them, the geometry of local twistors and tractor calculus. (Received September 02, 2009)

1056-53-509 **Corey A. Hoelscher*** (coreyah@math.rutgers.edu), Department of Mathematics, 110 Frelinghuysen Road, Piscataway, NJ 08854. *Low dimensional cohomogeneity one manifolds.*

In essence, a cohomogeneity one manifold is a manifold with lots of symmetry, to the degree that it is almost a homogeneous space. More precisely, it is a Riemannian manifold $M$ with a compact group $G$ of isometries which acts on $M$ with a one dimensional orbit space $M/G$. Such manifolds are important in many areas of geometry and in mathematical physics. In this talk we will describe the classification of compact simply connected cohomogeneity one manifolds in dimensions 5, 6, and 7. We will also discuss the topological properties of these manifolds including the diffeomorphism characterization of them in dimensions 5 and 6. (Received September 10, 2009)

1056-53-529 **Christina Sormani** and **Guofang Wei*** (wei@math.ucsb.edu). *The Cut-off Covering Spectrum.*

We introduce the $R$ cut-off covering spectrum and the cut-off covering spectrum of a metric space or Riemannian manifold. The spectra measure the sizes of localized holes in the space and are defined using covering spaces called $\delta$ covers and $R$ cut-off $\delta$ covers. They are investigated using $\delta$ homotopies which are homotopies via grids whose squares are mapped into balls of radius $\delta$.

On locally compact spaces, we prove that these new spectra are subsets of the closure of the length spectrum. We prove the $R$ cut-off covering spectrum is almost continuous with respect to the pointed Gromov-Hausdorff convergence of spaces and that the cut-off covering spectrum is also relatively well behaved. This is not true of the covering spectrum defined in our earlier work which was shown to be well behaved on compact spaces. We close by analyzing these spectra on Riemannian manifolds with lower bounds on their sectional and Ricci curvature and their limit spaces. (Received September 11, 2009)

1056-53-551 **Irina A Kogan*** (iakogan@ncsu.edu), North Carolina State University, Campus Box 8205, Raleigh, NC 27695. *Variational calculus in non-commutative frames.* Preliminary report.

Certain variational problems, in particular, problems with symmetries and problems on Lie groups, can be studied more efficiently by utilizing non-commutative bases of vector fields that are properly adapted to the geometry of a problem. We will discuss some of the aspects of performing variational calculus relative to such frames, including derivation of Euler-Lagrange equations and establishing Noether correspondence between symmetries and conservation laws. (Received September 12, 2009)

1056-53-562 **M dunajski***, DAMTP, Wilberforce Road, m.dunajski@damtp.cam.ac.uk, Cambridge, England. *Four-dimensional metrics conformal to Kahler.*

I shall discuss my recent work with Paul Tod and give some necessary and sufficient conditions on a Riemannian metric $(M, g)$ in four dimensions for it to be locally conformal to Kähler. If the conformal curvature is non anti–self–dual, the self–dual Weyl spinor must be of algebraic type $D$ and satisfy a simple first order conformally invariant condition which is sufficient and necessary for the existence of a Kähler metric in the conformal class. In the anti–self–dual case we establish a one to one correspondence between Kähler metrics in the conformal class and non–zero parallel sections of a certain connection on a natural rank ten vector bundle over $M$. We use this characterisation to provide examples of ASD metrics which are not conformal to Kähler. We establish a link between the 'conformal to Kähler condition' in dimension four and the metrisability of projective structures in dimension two. A projective structure on a surface $U$ is metrisable if and only if the induced (2, 2) conformal structure on $M = TU$ admits a Kähler metric or a para-Kähler metric. (Received September 12, 2009)

1056-53-566 **Charmaine Sia*** (sia@mit.edu). *Duality Properties of Indicatrices of Knots.*

The bridge index and superbridge index of a knot are important invariants in knot theory. We define the bridge map of a knot conformation, which is closely related to these two invariants, and interpret it in terms of the tangent indicatrix of the knot conformation. Using the concepts of dual and derivative curves of spherical curves as introduced by Arnold, we show that the graph of the bridge map is the union of the binormal indicatrix and its antipodal curve. Similarly, we define the inflection map of a knot conformation, interpret it in terms of the binormal indicatrix and express its graph in terms of the tangent indicatrix. This duality relationship is also studied for another dual pair of curves, the normal and Darboux indicatrices of a knot conformation. (Received September 12, 2009)

1056-53-593 **Jonathan E Holland*** (jeh89@pitt.edu), Department of Mathematics, University of Pittsburgh, 301 Thackeray Hall, Pittsburgh, PA 15260. *Third order odes and conformal Finsler geometries.*

We discuss contact invariant structures on the space of solutions of a third order ordinary differential equation. When the Wünschmann invariant vanishes, it is a result Chern that the space of solutions admits a conformal Lorentzian structure. In the general case, we define the notion of a causal structure, and show that the space of solutions supports one. The Wünschmann invariant is then related to the projective curvature of the curve cut out by the causal structure in the projective tangent space. When the Wünschmann vanishes, the causal structure is then precisely the sheaf of null geodesics of the Chern conformal structure. We then introduce a Lagrangian and associated Hamiltonian from which the degenerate conformal Lorentzian metric and and the ultrahyperbolic metric of Nurowski are given on certain natural associated bundles. Finally, the results of Frittelli, Kozameh, and Newman on complete solutions of the eikonal equation are generalized. (Received September 14, 2009)

1056-53-728 **Amine Fawaz*** (fawaz_a@utpb.edu), The University of Texas of the Permian Basin, Department of Mathematics, 4901 E. University, Odessa, TX 79762. *Volume of Meromorphic Vector fields on Flat Tori.* Preliminary report.

We define the volume of flows on riemannian manifolds, then we derive the Euler-Lagrange equations in dimension 2. We prove that holomorphic foliations on flat tori are critical and we compute their volumes. Finally, we give a lower bound for the volume of meromorphic foliations on flat tori. (Received September 16, 2009)

1056-53-792 **Katja Sagerschnig*** (katja.sagerschnig@univie.ac.at), Nordbergstraße 15, 1090 Vienna, Austria. *Generic rank two distributions on five-manifolds and associated conformal structures.*

It follows from a classical paper of E. Cartan that maximally non-integrable distributions of rank 2 on 5-manifolds have an equivalent description as parabolic geometries. Based on Cartan's work, P. Nurowski associated to such a distribution a natural conformal class of pseudo-Riemannian metrics of signature $(2, 3)$. In this talk we will discuss how methods from the theory of parabolic geometries can be employed for the study of these conformal structures. The presentation may include the construction of metrics from the conformal class based on the notion of a generalized contact form, a characterization of conformal structures associated to 2-distributions among all conformal structures of signature $(2, 3)$, and the decomposition of the space of conformal Killing fields into symmetries of the distribution and almost Einstein scales. (Received September 17, 2009)

1056-53-805 **Igor Zelenko*** (zelenko@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843-3368. *Symplectification, Generalized Tanaka Prolongations, and Geometry of Distributions.* Preliminary report.

The talk is devoted to local geometry of distributions (subbundles of tangent bundles) on manifolds. We will present quite general results on the finiteness of dimension of symmetry group and on the construction of the canonical frames for distributions of any rank. One of the corollaries is that a rank 2 nonholonomic distribution is either the Goursat distribution (i.e. a distribution locally isomorphic at generic point to the natural distribution on jet spaces of scalar functions of one variable) or has finite dimensional algebra of infinitesimal symmetries. Our method is a combination of ideas from Optimal Control Theory (a symplectification procedure) and the generalized Tanaka prolongation procedure for filtered structures on manifolds. The talk is based on the joint work with Boris Doubrov. (Received September 17, 2009)

1056-53-1127 **Andrew Bucki*** (ajbucki@lunet.edu), Department of Mathematics, Langston University, Langston, OK 73050. *Symmetric Almost r-Paracontact Connections.* Preliminary report.

If $\varphi$ is a tensor field of type $(1, 1)$, $\xi_1, \xi_2, \ldots, \xi_r$ are linearly independent vector fields, and $\eta^1, \eta^2, \ldots, \eta^r$ are 1-forms on a manifold $M$ satisfying $\varphi^2 = Id - \eta^\alpha \otimes \xi_\alpha$ and $\varphi(\xi_\alpha) = 0$, then $(M, \varphi, \xi_\alpha, \eta^\alpha)$ is an almost $r$-paracontact manifold. A linear connection $\Gamma$ on $M$ is an almost $r$-paracontact connection if the structure tensor field $\varphi$, vector fields $\xi_\alpha$, and 1-forms $\eta^\alpha$ are parallel with respect to $\Gamma$. In this paper, the necessary and sufficient conditions for existence of a symmetric almost $r$-paracontact connection are found. Examples of symmetric almost $r$-paracontact connections are presented. Some applications of almost $r$-paracontact connections are discussed. (Received September 21, 2009)

1056-53-1227 **D. B. McReynolds*** (dmcreyn@math.uchicago.edu), Chicago, IL 60647, and **Alan W. Reid**, Austin, TX. *The genus spectrum of a hyperbolic 3-manifold.*

In this talk, I will discuss recent work with Alan Reid on higher dimensional spectra. The focus will be on totally geodesic surfaces in hyperbolic 3-manifolds. (Received September 21, 2009)

1056-53-1316 **Vincent Bonini*** (vbonini@calpoly.edu), Department of Mathematics, California Polytechnic State University, San Luis Obispo, CA 93407, **Jie Qing** (qing@ucsc.edu), Department of Mathematics, University of California, Santa Cruz, Santa Cruz, CA 95064, and **Jose Espinar** (jespinar@ugr.es), Departmento de Geometría y Topología, Universidad de Granada, E-18071 Granada, Spain. *Hypersurfaces in Hyperbolic Poincaré Manifolds and Conformally Invariant PDEs.*

Geometric foliations of manifolds often have physical significance and can help to characterize the underlying geometry and topology of their ambient space. In this talk we focus on a preliminary result for hyperbolic Poincaré manifolds, which serve as prototypical models for asymptotically hyperbolic manifolds. We derive a relationship between the eigenvalues of the Schouten tensor of a conformal representative of the conformal infinity of a hyperbolic Poincaré manifold and the principal curvatures on the level sets of its uniquely associated defining function. This relationship gives a correspondence between Weingarten hypersurfaces in hyperbolic Poincaré manifolds and conformally invariant equations on the conformal infinity and leads to some interesting geometric foliations. (Received September 21, 2009)

1056-53-1467 **Timothy E Goldberg*** (goldberg@math.cornell.edu), Department of Mathematics, Malott Hall, Cornell University, Ithaca, NY 14850. *Singular reduction of generalized complex manifolds.*

In this paper we develop the analogue of Sjamaar and Lerman's singular reduction of Hamiltonian symplectic manifolds in the context of Hamiltonian generalized complex manifolds, in the sense of Lin and Tolman. Specifically, we prove that if a compact Lie group acts on a generalized complex manifold in a Hamiltonian fashion, then the stratification of the global quotient of the manifold by orbit types induces a stratification of the Lin–Tolman quotient, and each of these strata naturally inherits a generalized complex structure. (Received September 21, 2009)

1056-53-1590 **Emily Proctor** and **Elizabeth Stanhope***, 0615 SW Palatine Hill Rd., Portland, OR 97219. *Spectral bounds on 2-orbifold diffeomorphism type.*

We show that any collection of isospectral 2-orbifolds sharing a lower bound on sectional curvature contains orbifolds of only finitely many diffeomorphism types. (Received September 22, 2009)

1056-53-1661 **George Arthur Sparling*** (gnilraps@gmail.com), 301 Thackeray Hall, University of Pittsburgh, Pittsburgh, PA 15260. *The exceptional Lie group $\mathbb{G}_2$ and gravity.*

It will be shown that the Lie group $\mathbb{G}_2$ arises naturally in Einstein's gravity. Then the $\mathbb{G}_2$ approach will be linked to the primordial theory of the author and Phillip Tillman. (Received September 22, 2009)

1056-53-1720 **Christopher R Godbout*** (crg6@lehigh.edu), 837 Almond St., Philadelphia, PA 19125. *Behavior of the Chern-Simons forms under the Ricci flow.*

The Chern-Simons forms are odd-dimensional secondary characteristic classes. While they are elements of cohomology group, they are determined by the connection and curvature forms of a manifold. Chern and Simons showed that this form is a geometric invariant (and is a gauge invariant modulo addition of an integer).

To gain a better understanding of these forms, the author studies the behavior of the forms as the Ricci flow is applied to them. In particular, this behavior is examined on warped products of spheres, Berger collapsed spheres, and generalizations of the Berger spheres. (Received September 22, 2009)

1056-53-1752 **Ivko M Dimitric*** (ivko@psu.edu), Penn State University Fayette, 1 University Dr., Uniontown, PA 15401. *Curvature-adapted hypersurfaces of 2-type in quaternion space forms.*

In a curvature-adapted hypersurface $M$ of a quaternion-Kähler manifold the maximal quaternionic subbundle in $TM$ and its orthogonal complement are invariant subspaces of the shape operator at each point. We classify curvature-adapted hypersurfaces $M$ of non-flat quaternion space forms $\mathbb{H}P^m$ and $\mathbb{H}H^m$ that are of Chen 2-type in an appropriately defined (pseudo) Euclidean space of quaternion-Hermitian matrices. This means that the position vector of $M$ in that matrix space is built from vector eigenfunctions of the Laplacian belonging to two different eigenspaces. In the quaternion projective space they include all geodesic hyperspheres except one (which is of 1-type), two series of tubes about canonically embedded $\mathbb{H}P^k \subset \mathbb{H}P^m$, $1 \leq k < m$, and two particular tubes about canonically embedded $\mathbb{C}P^m \subset \mathbb{H}P^m$, whereas in $\mathbb{H}H^m$ the list is reduced to geodesic spheres and tubes of arbitrary radius about totally geodesic quaternionic hyperplane $\mathbb{H}H^{m-1}$. (Received September 22, 2009)

1056-53-2066 **Christopher R Lee*** (leec@up.edu), University of Portland, Buckley Center 262, MSC 60, 5000 N Willamette Blvd., Portland, OR 97203. *Uniqueness of folded symplectic toric manifolds.* Preliminary report.

A folded symplectic toric manifold is a $2n$-dimensional manifold along with an effective action of the $n$-torus admitting a moment map with respect to a closed two-form that degenerates in a controlled fashion along a hypersurface. Unlike their symplectic counterparts, folded symplectic toric manifolds cannot be classified combinatorially. On the other hand, given $\Sigma$, a smooth surface with corners such that $H^2(\Sigma;\mathbb{Z}) = 0$, and an orbital moment map on $\Sigma$ we prove that there is at most one orientable, folded four-dimensional symplectic toric manifold whose orbit space coincides with $\Sigma$. We also discuss how degree two cohomology classes of $\Sigma$ parameterize isomorphism classes of folded symplectic toric four-manifolds. (Received September 23, 2009)

# 54 ► General topology

1056-54-109 **Okan Gurel*** (protein@attglobal.net), 630 First Avenue, New York, NY 10016, and **Demet Gurel**, 27-33 W23 St, New York, NY 10010. *Fibonacci Hexagon and Genetic Tableau.*

The Fibonacci numbers and their corresponding Fibonacci squares [1202, Liber Abaci] not only show the morphogenesis of sea shells, but the fundamental basis of life. The number of the amino acids (phenotype) and their distribution are determined by the Fibonacci numbers (0 1 1 2 3 5 8). Fibonacci squares corresponding to Fibonacci numbers cover the planar space by spiraling out. We show that four concentric hexagons corresponding to (0 1 1 2) represent a bundle of six Fibonacci spirals, which we named the Fibonacci Hexagon. Rearranging "The Genetic Code", a matrix with both rows and columns as (TCAG), by elements of the cyclic group, (CGAT, CTGA, CATG) defined on the Genetic Tetrahedron yields the Genetic Tableau, [1969 (January), The Structure of the Genetic Code, IBM NYSC 320-2963]. This brings out the asymmetric structure of the genetic code. The sequence of amino acids 1 through 20, Gly to Trp, in increasing number of carbons in their residues, forming six spiraling triangles with edges (3 5 8) cover the Fibonacci hexagon. This covering corresponds precisely to the positions of the amino acids on the asymmetric Genetic Tableau (genotype). (Received July 27, 2009)

1056-54-131 **Christian Laing*** (cl84@nyu.edu) and **De Witt Sumners**. *The writhe of oriented polygonal graphs.*

The directional writhe of a simple closed curve is the sum of the signed crossings in the projection of the curve in the given direction. The writhe of a simple closed curve in 3-space is the average over all directions of directional writhe. We extend this definition to apply to edge-oriented finite spatial graphs. This definition of writhe covers spatial polygonal arcs and non-connected graphs, and does not require the ad hoc closing of arcs to eliminate the problems posed by endpoints. The writhe is used to describe and compare the spatial structure of DNA, RNA and proteins. This talk will discuss some of these applications, and give a new formula for the additivity of writhe for structures constrained to separate topological domains. (Received July 28, 2009)

1056-54-408 **Su Gao** and **Vincent Kieftenbeld*** (kieftenbeld@unt.edu), University of North Texas, Department of Mathematics, 1155 Union Circle #311430, Denton, TX 76203–501. *Resolvable maps preserve complete metrizability.*

Let $X$ be a Polish space, $Y$ a separable metrizable space, and $f\colon X \to Y$ a continuous surjection. We prove that if the image under $f$ of every open set or every closed set is resolvable, then $Y$ is Polish. This generalizes similar results by Sierpiński, Vainštain, and Ostrovsky. (Received September 04, 2009)

1056-54-1055 **Adam C McDougall*** (acmcdoug@math.uiowa.edu), Department of Mathematics, 14 MacLean Hall, The University of Iowa, Iowa City, IA 52252. *Defining Khovanov Homology in 3-Manifolds Using a Diagramless Theory.*

In 2000, Khovanov defined a link homology which can be viewed as a categorification of the Jones polynomial. Today, the study of Khovanov homology and other link homologies are quite common. To define a link homology one typically builds chain modules from a given projection of that link (called a 'diagram'). Extra work must be done to show this is a link invariant. Additionally, generalizing such homology theories to other 3-manifolds can be a very difficult problem.

In this talk, a diagramless link homology is defined that is related to the Khovanov homology of the given link. Unlike diagram-based homology theories, this diagramless homology can be defined for links in most 3-manifolds. (Received September 21, 2009)

1056-54-1264 **Rajagopalan —— minakshisundaram*** (mrajagopalan@juno.com), Department of mathematics, Tennessee State University, 3500 John Merritt Boulevard, Nashville, TN 37209. *Shifts on compact metric o-dimensional spaces.* Preliminary report.

Acompact metric zero dimensional space admits a complex shift. it may or may not admit a real shift. Metric compact scattered spaces admit a preshift and hence a real shift. this solves some problems raised by K.Sundaresan. (Received September 21, 2009)

1056-54-1389 **Aldo-Hilario Cruz-Cota*** (cruzal@gvsu.edu), Department of Mathematics, Grand Valley State University, A-2-178 Mackinac Hall, 1 Campus Drive, Allendale, MI 49401-6495. *The Moduli space of singular Euclidean structures on a sphere with 4 cone points whose cone angles are integer multiples of $\frac{2\pi}{3}$ but less than $2\pi$.* Preliminary report.

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*. 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.

In this paper I will describe a parameter space for the moduli space of singular Euclidean structures on a sphere with 4 cone points whose cone angles are integer multiples of $\frac{2\pi}{3}$ but less than $2\pi$. This classification involves finding a canonical decomposition of a singular Euclidean surface into two subsets called *Voronoi cells*. (Received September 21, 2009)

1056-54-2096 **Emily R Landes*** (elandes@math.utexas.edu), Univeristy of Texas, Austin, Department of Mathematics, 1 Univeristy Station C1200, Austin, TX 78712. *Identifying the Canonical Component for the Whitehead Link.* Preliminary report.

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 6 points and discuss the canonical components for a few other hyperbolic 2-component link complements. (Received September 23, 2009)

# 55 ► Algebraic topology

1056-55-161 **Ainhoa Berciano** (ainhoa.berciano@ehu.es), University of the Basque Country, Departamento de Didáctica de la Matemátic, Ramón y Cajal, 72., 48014-Bilbao(Bizkaia, Spain, **Sean Evans** (sme26@pitt.edu), University of Pittsburgh, Department of Mathematics, Pittsburgh, PA 15260, and **Ronald Umble*** (ron.umble@millersville.edu), Millersville University of Pennsylvania, Department of Mathematics, 203 Wickersham Hall, Millersville, PA 17551. *$A_\infty$-Bialgebras of Type $(m,n)$.*

An $A_\infty$*-bialgebra of type* $(m,n)$ is a Hopf algebra $H$ equipped with a "compatible" operation $\omega_m^n : H^{\otimes m} \to H^{\otimes n}$ of positive degree. We determine the structure relations for $A_\infty$-bialgebras of type $(m,n)$ and construct a purely algebraic example for each $m \geq 2$ and $m+n \geq 4$. (Received August 09, 2009)

1056-55-289 **Matthew S. Miller*** (matthew.miller@bucknell.edu), Department of Mathematics, Bucknell University, Lewisburg, PA 17837, and **Max Wakefield** (wakefiel@usna.edu), 572C Holloway Road, Chauvenet Hall, United States Naval Academy, Annapolis, MD 21402-5002. *Hypergraphic subspace arrangements.*

We will discuss how the combinatorics of hypergraphs provide information about the topology of the complex complement of certain subspace arrangements. Through examples we will describe combinatorial conditions that have bearing on higher order products in the cohomology of the complement of certain subspace arrangements. (Received August 25, 2009)

1056-55-544 **Michael P. Allocca*** (mpallocc@ncsu.edu), North Carolina State University, Department of Mathematics, Campus Box 8205, Raleigh, NC 27695. *Homomorphisms of $L_\infty$ Modules.*

$L_\infty$ algebras are natural generalizations of Lie algebras from a homotopy perspective. Many concepts from classical Lie algebra representation theory also generalize up to homotopy in the form of $L_\infty$ modules. We discuss building classical Lie module homomorphisms in this generalized context and define homomorphisms of $L_\infty$ modules. (Received September 11, 2009)

1056-55-611 **Chad D Giusti*** (cgiusti@uoregon.edu), Department of Mathematics, University of Oregon, Eugene, OR 97403. *Unstable Vassiliev Theory.*

We begin by constructing the spaces of plumbers' knots, which are piecewise linear with all pipes parallel to the axes. These knots are closely related to lattice knots and provide a new version of finite complexity knot theory which, in the limit, gives rise to classical knot theory. The rigid geometry of these spaces induces a combinatorial cellular structure. We exploit this to construct an algorithm for distinguishing the unstable isotopy class of a plumbers' knot. This algorithm has demonstrated that, for example, there are seven components of the space of plumbers' knots with five moves, though only three classical knot types are present.

We next describe the notion of the Vassiliev derivative for a singular plumbers' knot, extending the definition to include singularities other than collections of isolated double-points. This allows us to import Vassiliev's original techniques to our finite-complexity setting, where we can exploit the cell structure to explicitly compute Vassiliev derivatives while retaining geometric information. This result opens the door to constructing new Vassiliev-style knot invariants and/or seeing the strength of finite-type invariants once we understand the behavior of Vassiliev derivatives under stabilization (subdivision of pipes). (Received September 14, 2009)

1056-55-727 **Eric B. Kahn*** (ekahn@bloomu.edu), 222 Ben Franklin Hall, Bloomsburg University, Bloomsburg, PA 17815. *The Generalized Burnside and Representation Rings.*

For groups G and H, the generalized Burnside and representation rings are the Grothendieck constructions of the semiring of (GxH)-sets with a free H-action and of the semiring of rational (GxH)-modules that are free as rational H-modules respectively. The canonical map between these two rings mapping the isomorphism class of a G-set X to the class of its permutation module is known as the linearization map. For p a prime number and H the unique group of order p, we describe the generators of the kernel of this map in the cases where G is an elementary abelian p-group or a cyclic p-group. (Received September 16, 2009)

1056-55-923 **Nicholas A Scoville*** (nicholas.scoville@dartmouth.edu), 6188 Kemeny Hall, Dartmouth College Mathematics Dept., Hanover, NH 03755. *A Metric for Homotopy Types.* Preliminary report.

Let C be the collection of CW complexes under the equivalence relation of homotopy type, and let * be the equivalence class of contractible spaces. We will motivate the definition of the distance d between two objects in the collection C. This distance is based on the classical notion of the cone length of a space. We will then show that for any positive real number r, there exists a space X(r) such that the distance between X(r) and * is equal to r. The proof utilizes a number theory result concerning Egyptian Fractions. This shows that all positive real values are realized in the metric space (C,d). (Received September 18, 2009)

1056-55-1201 **Karleigh Frederick**, **Samantha Hilker** and **Megan Savage*** (mls033@shsu.edu), 2537 Pine Shadows Dr, Apt 618, Huntsville, TX 77340. *A Knot or Not a Knot?* Preliminary report.

This talk will examine multiplicative Conway notation, and try to answer the question: Can a multiplicative Conway notation be examined to definitively tell whether it will yield a knot or a link? Initially, we focused on finding patterns of even and odd numbers embedded in the sequence of numbers. The ambiguity of this process made us search for more general methods. From this, we developed a method for following a single strand of a tangle as it wound through the notation, enabling us to predict when the Conway notation would yield a knot or a link. We will explain the method with many examples. (Received September 21, 2009)

1056-55-1616 **Eric L Finster*** (ericfinster@gmail.com), University of Virginia, Department of Mathematics, PO Box 400137, Charlottesville, VA 22904. *Stabilization of Homotopy Limits.*

This talk will outline the major results of my thesis work, which describes a natural filtration, inspired by Goodwillie's Calculus of Functors, of the stable homotopy type of the space $\mathrm{holim}_{\mathcal{C}} F$ for a given functor $F$ :

$\mathcal{C} \to \mathcal{T}op$, where $\mathcal{C}$ is some small indexing category. More concretely, we construct a sequence of categories $\mathcal{C} = \mathcal{C}_1 \subseteq \mathcal{C}_2 \subseteq \mathcal{C}_3 \cdots$ derived from $\mathcal{C}$ such that, under favorable conditions, we have an equivalence

$$\Sigma^\infty \mathrm{holim}_{\mathcal{C}} F \simeq \mathrm{holim}\left(\cdots \to \mathrm{holim}_{\mathcal{C}_2} \Sigma^\infty F \to \mathrm{holim}_{\mathcal{C}_1} \Sigma^\infty F\right)$$

When $F$ is constant, we recover the results of G. Arone on the derivatives of the functor $\Sigma^\infty \mathrm{Map}(K, X)$, whereas for $\mathcal{C}$ discrete we recover the classical Snaith splitting of a product. The spectral sequence obtained from this filtration can be considered as an alternative to the Bousfield-Kan spectral sequence of a cosimplicial space. (Received September 22, 2009)

1056-55-1638 **Gunnar Erik Carlsson*** (gunnar@math.stanford.edu), Mathematics Department, Stanford University, Stanford, CA 94305. *Algebraic aspects of persistence.*

I will talk about various kinds of persistence, which is a methodology which allows one to study topological properties of point cloud data sets. This will include multidimensional persistence as well as zig-zag persistence, together with methods for carrying out computations. (Received September 22, 2009)

1056-55-1666 **Brie A Finegold*** (briefly@math.ucsb.edu), Department of Mathematics South Hall Rm 6607, University of California, Santa Barbara, CA 93106. *The Third Torus Complex is Simply Connected.*

The 3rd Torus Complex is a simplicial complex on which $SL(3, Z)$ acts co-compactly. The action is analogous to the action of $SL(2, Z)$ on the Farey Graph (the curve complex of the Torus). I will sketch a proof that the 3rd Torus Complex is simply connected and display a palindromic presentation of $SL(3, Z)$ that results from using basic ideas about Complexes of Groups. A palindromic presentation is one in which any relator written backwards is again a relator. (Received September 22, 2009)

1056-55-1671 **Mokhtar B. Aouina*** (mokhtar.aouina@jsums.edu), JSU Box 17610, Department Of Mathematics, Jackson, MS 39217. *A new argument for the exactness at the (n+1)-thickening term in the C.T.C Wall's exact sequence for thickenings.*

A fundamental problem in differential topology is to enumerate the set of compact manifolds up to diffeomorphism within a given homotopy type. In 1966, C. T. C Wall in his paper "Classification problems in differential topology-IV. Thickenings" introduced the concept of thickening to address this problem. He constructed an exact sequence where he related the n-thickenings of a finite complex to its (n+1)-thickenings. Wall called this exact sequence the suspension theorem. Through our investigation of that theorem, we discovered a gap in Wall's proof dealing with the exactness at the (n+1)-thickening term. We will provide a new argument to fill in this gap. This is a published and joint work with J. R. Klein. (Received September 22, 2009)

1056-55-1879 **Michael Hopkins*** (mjh@math.harvard.edu), Department of Mathematics, 1 Oxford Street, Cambridge, MA 02138. *On the Kervaire Invariant Problem.*

I will describe the history of the "Kervaire Invariant One" problem in algebraic topology, and it's recent solution by Mike Hill, myself, and Doug Ravenel. (Received September 22, 2009)

1056-55-2063 **Henry Adams*** (henrya@math.stanford.edu), 76 Barnes Court, #101, Stanford, CA 94305, and **Gunnar Carlsson** and **Atanas Atanasov**. *Topological data analysis and the nudged elastic band method.* Preliminary report.

Imagine one has a dataset $X$ which is a finite and possibly noisy sampling of an unknown space $Y \subset \mathbb{R}^n$. Using only $X$, can one recover information about $Y$? With persistent homology, one can estimate the homology groups $H_*(Y)$ (see *Computing persistent homology*). We present another approach, in which we assume $Y$ is a CW complex and we approximate its $k$-skeleta $Y^k$. For $k = 1$, our approach is an adaptation of the nudged elastic band method (NEB) from chemistry, which locates minimum energy transition paths between stable configuration states (see *Nudged elastic band method for finding minimum energy paths of transitions*). We note two ways ways in which our NEB method may be of use. First, in the persistent homology pipeline, it may help one find a model for $Y$ matching the estimated homology groups. Second, it may reduce the need to restrict to dense core subsets of $X$, as is often necessary before applying persistent homology. We test the NEB method on several datasets. (Received September 23, 2009)

1056-55-2135 **Rebecca E Field*** (fieldre@jmu.edu), MSC 1911, Department of Mathematics, Roop Hall, James Madison University, Harrisonburg, VA 22807. *The descent spectral sequence for $SL_2$ and $PSL_2$.*

I will present joint work with Ian Grojnowski on using the descent spectral sequence to compute $E^*BG$ for $E^*$ any complex oriented cohomology theory, and $G$ a reductive group. In this talk, I'll just explain this for $(P)SL_2$. (Received September 23, 2009)

# 57 ► Manifolds and cell complexes

1056-57-47 **Andrew Elliott*** (elflord@rice.edu), Math Department – MS 136, Rice University, 6100 S. Main St., Houston, TX 77005. *Graph-based methods establishing nontriviality of state cycle Khovanov homology classes.*

We determine when certain state cycles represent nontrivial Khovanov homology classes by analyzing features of the state graph. Using this method, we are able to produce hyperbolic knots with arbitrarily many diagonals containing nontrivial state cycle homology classes. This gives lower bounds on the Khovanov width of knots whose complexity precludes computation of the full homology. (Received July 13, 2009)

1056-57-148 **Allison Henrich**, **Noël MacNaughton**, **Sneha Narayan**, **Oliver Pechenik** and **Jennifer Townsend*** (jtownsen@scrippscollege.edu), 1030 Columbia Ave, Claremont, CA 91711. *Classical and Virtual Pseudodiagram Theory and New Bounds on the Unknotting Numbers and Genus of Knots.*

A pseudodiagram is a diagram of a knot with some crossing information missing. We review and expand the theory of pseudodiagrams introduced by R. Hanaki in 2009. We then extend this theory to the realm of virtual knots, a generalization of knots. In particular, we address the issue of how much crossing information must be known to conclude that a diagram is a diagram of the unknot. We also consider how much information is necessary to identify a non-trivial knot, a classical knot, or a non-classical knot. We then apply pseudodiagram theory to develop new upper bounds on unknotting number, virtual unknotting number, and genus. (Received August 04, 2009)

1056-57-216 **Cornelia A. Van Cott*** (cvancott@usfca.edu), University of San Francisco, Math Department, 2130 Fulton Street, San Francisco, CA 94117. *An obstruction to slicing iterated Bing doubles.*

Beginning with a knot $K$, one can construct a sequence of links called iterated Bing doubles $BD_n(K)$. Determining when iterated Bing doubles are slice has proved to be a difficult problem, for many of the usual tools from classical link theory fail in the case of Bing doubles. We prove the following result: If $BD_n(K)$ is slice for some $n$, then $K$ is algebraically slice. (Received August 15, 2009)

1056-57-218 **Chia-Yen Tsai*** (ctsai6@math.uiuc.edu), University of Illinois at Urbana-Champaign, Department of Mathematics, 1409 West Green Street, Urbana, IL 61801. *The most interesting surface homeomorphisms.*

One way to study non-Euclidean geometry is to understand homeomorphisms of a surface S onto itself. Among surface homeomorphisms, the most interesting ones are pseudo-Anosov which have the behavior of expanding S in one direction and contracting in a complementary direction by the same amount. We study how pseudo-Anosov maps behave when we change the topology of S. On the one hand, we can analyze the minimal length distortion of S if S is attached a Riemannian matric. On the other hand, we can study the infimum distortion of the combinatorial structure of S. (Received September 22, 2009)

1056-57-358 **Thomas W Mattman*** (TMattman@CSUChico.edu), Department of Mathematics, California State University, Chico, Chico, 95926, and **Pablo Solis** (pablo@math.berkeley.edu), Department of Mathematics, University of California, Berkeley. *A proof of the Kauffman–Harary Conjecture.*

We prove the Kauffman–Harary Conjecture, posed in 1999: given a reduced, alternating diagram $P$ of a knot with prime determinant $p$, every non-trivial Fox $p$-coloring of $P$ will assign different colors to different arcs. (Received September 01, 2009)

1056-57-422 **Colin Adams** (Colin.C.Adams@williams.edu), **Dan Collins** (djc224@cornell.edu), **Katherine Hawkins** (Katherine.L.Hawkins@williams.edu), **Charmaine Sia** (sia@mit.edu), **Rob Silversmith*** (ras1@williams.edu) and **Bena Tshishiku** (tshishikub10@mail.wlu.edu). *Planar and Spherical Stick Indices of Torus Knots.*

The stick index of a knot is the least number of line segments required to build the knot in space. We define two analogous 2-dimensional invariants, the planar stick index and the spherical stick index. We find bounds on these quantities in terms of other knot invariants, and give planar stick and spherical stick constructions for torus knots. (Received September 09, 2009)

1056-57-427 **Oliver Dasbach** and **Adam Lowrance*** (alowrance@math.uiowa.edu), Department of Mathematics, University of Iowa, 14 MacLean Hall, Iowa City, IA 52242-1419. *Turaev genus, knot signature, and the knot homology concordance invariants.*

Each knot diagram has an associated Turaev surface, a certain Heegaard surface in the three-sphere on which the knot has an alternating projection. The Turaev genus of a knot is defined to be the minimum genus of any Turaev surface for the knot, where the minimum is taken over all diagrams. From any knot diagram, one can find upper and lower bounds on knot signature, the Ozsváth-Szabó $\tau$ invariant, and Rasmussen's $s$ invariant. We show how these bounds relate to Turaev genus, and consequently develop a new lower bound for Turaev genus. (Received September 06, 2009)

1056-57-546 **Colin Adams**, **Dan Collins*** (djc224@cornell.edu), **Katherine Hawkins**, **Charmaine Sia**, **Rob Silversmith** and **Bena Tshishiku**. *The Spherical Stick Index and Compositions of Trefoils.*

The stick index of a knot is the least number of line segments required to build the knot in space. We define a related invariant, the spherical stick index of a knot, as the least number of great circle arcs required to draw a diagram of that knot on a sphere. We look at the behavior of this invariant for compositions of trefoil knots, and find a surprising dependence on the handedness of the composed trefoils. (Received September 11, 2009)

1056-57-556 **Daniel C. Cohen** and **Michael J. Falk*** (michael.falk@nau.edu), Dept. of Mathematics and Statistics, Flagstaff, AZ 86011-5717, and **Richard Randell**. *Representations of arrangement groups.*

We describe a natural homomorphism $\varphi$ from the fundamental group $G$ of the complement of a complex projective line arrangement to a product $A$ of free groups. The image of $\varphi$ is a normal subgroup of $A$, and the cokernel of $\varphi$ is free abelian. We give a combinatorial interpretation cokernel in terms of flows on a graph, and derive a formula for the rank.

Using a generalization of a result of T. Stanford on Brunnian braids, we derive an easily verified condition for $\varphi$ to be injective. In this case $G$ is residually free, torsionfree, residually torsionfree nilpotent, and combinatorially determined. The realization of $G$ inside $A$ also yields a precise calculation of the cohomological finiteness type of $G$. We demonstrate with several examples. (Received September 12, 2009)

1056-57-615 **Philip C Huling*** (hulingpc@slu.edu), 314 N 49th St, Belleville, IL 62226. *Rigidity of Hyperbolic Orbifolds.*

We define a hyperbolic $n$-orbifold to be the quotient of hyperbolic $n$-space, $\mathbb{H}^n$, by a discrete subgroup, $\Gamma$, of Isom($\mathbb{H}^n$). If $\Gamma$ is cofinite in Isom($\mathbb{H}^3$), then the size of its deformation space (up to conjugation) is well known. However, we may view $\Gamma$ as being a subset of Isom($\mathbb{H}^4$) to investigate how this inclusion into a higher dimension allows for more deformations in the group. We find the dimension of the deformation space of a large class of cofinite Coxeter groups and then develop tools to analyze the deformation space of groups commensurable with them. Specifically, we are able to describe the deformation spaces of Bianchi groups which have a finite index Coxeter subgroup. (Received September 14, 2009)

1056-57-619 **Patrick M Gilmer*** (gilmer@math.lsu.edu). *Heegaard genus, cut number, weak p-congruence, and quantum invariants.*

Let $p = 2d + 1$ be a prime bigger than 3. We use quantum invariants to define an invariant of closed oriented 3-manifolds, $j_p$, which lies in the non-negative integers. We show that $j_p$ is an invariant of weak $p$-congruence. Let $h(M)$ denote the Heegaard genus of a closed oriented 3-manifold $M$ , and $c(M)$ denote its cut number. We show

$$0 \leq c(M) \leq \frac{j_p(M)}{d-1} \leq g(M).$$

(Received September 14, 2009)

1056-57-705 **Sergei Chmutov*** (chmutov@math.ohio-state.edu), The Ohio State University, 1680 University Drive, Mansfield, OH 44906. *First coefficient of the Conway polynomial of virtual links.* Preliminary report.

Theorems of Hosokawa, Hartley, and Hoste state that for an m-component link $L$ the coefficients $c_i(L)$ of the Conway polynomial of $L$ vanish when $i \leq m-2$ and the coefficient $c_{m-1}(L)$ depends only on the linking numbers $l_{ij}(L)$ between the $i$-th and $j$-th components of $L$. This coefficient is equal to the determinant of a certain matrix composed of the linking numbers. This determinant can be computed using the matrix-tree theorem from graph theory.

For virtual links there are two different types of the linking number and two Conway polynomials, ascending and descending. We generalize the theorem above to virtual links. In this case the determinant representing $c_{m-1}(L)$ is related to the oriented version of the matrix-tree theorem. This is a joint work with my students Z.Cheng, T.Dokos, and J.Lindquist. (Received September 16, 2009)

1056-57-918 **Marion Moore*** (marion@math.ucdavis.edu), 635 Adams St, Apt 8, Davis, CA 95616. *alpha-Sloped Thin Position for 3-manifolds.*

We introduce the concept of alpha-sloped thin position of 3-manifolds with torus boundary and examine its relationship to generalized Heegaard splittings of manifolds resulting from Dehn filling. We compare alpha-sloped thin position of 3-manifolds to other types of thin position for knots and 3-manifolds and discuss how this kind of decomposition gives a more organic picture of M and allows the structure of the manifold to dictate the most natural slope on the boundary. Additionally, we provide illustrative examples and questions motivating the study of alpha-sloped thin position. (Received September 18, 2009)

1056-57-966 **Bena Tshishiku*** (tshishikub10@mail.wlu.edu), 280 High Chaparral Dr., Martinez, GA 30907, and **Dan Collins**, **Charmaine Sia**, **Rob Silversmith**, **Katherine Hawkins** and **Colin Adams**. *Knots, Sticks, and Indicatrix.* Preliminary report.

In the study of knots and their invariants, it is often fruitful to consider the discrete case, that is, knots consisting of a finite number of straight line segments. Such knots are commonly known as stick knots. A knot indicatrix is a closed curve on the sphere that stores information about the knot's differential geometry. We consider the relations between stick knots, knot indicatrices, and knot invariants such as bridge number. (Received September 22, 2009)

1056-57-999 **Charles Frohman*** (frohman@math.uiowa.edu), Department of Mahtematics, The University of Iowa, Iowa City, IA 52242, and **Joanna Kania-Bartoszynska** (jkaniab@nsf.gov), National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230. *Reidemeister Torsion and the A-polynomial.*

Given a knot complement, we define a seminorm on the coordinate ring of the pillowcase using Reidemeister torsion. If the character variety of the knot is sufficiently nonsingular the radical of this seminorm detects the A-polynomial. (Received September 19, 2009)

1056-57-1085 **Matthew E Hedden*** (mhedden@math.msu.edu), Department of Mathematics, Michigan State University, Wells Hall, East Lansing, MI 48824, and **Charles Livingston** and **Daniel Ruberman**. *Topologically slice knots with non-trivial Alexander polynomial.*

We demonstrate a family of knots which bound topological locally flat disks in the four ball (i.e. are topologically slice) but do not bound smooth disks. Our examples are notable in that not only are their Alexander polynomials non-trivial, but they are not smoothly concordant to any knot with non-trivial Alexander polynomial. Moreover, we find that there are many such knots, in the following sense: If $\mathcal{C}_T$ denotes the subgroup of the smooth concordance group generated by topologically slice knots, and $\mathcal{C}_P$ denotes the subgroup of $\mathcal{C}_T$ generated by knots with Alexander polynomial one, then we show $\mathcal{C}_T/\mathcal{C}_P$ is infinitely generated. Our results use the Ozsváth-Szabó invariants in an essential way. (Received September 20, 2009)

1056-57-1173 **Charles D Frohman** and **Joanna Kania-Bartoszynska*** (jkaniaba@nsf.gov), National Science Foundation, 4201 Wilson Blvd., Arlington, VA 22230. *Quantum form of the Reidemeister torsion of a knot complement.*

J. Dubois defined a torsion invariant for knot complements. We will give an integral formula for this invariant that looks like a limit of quantum invariants. (Received September 21, 2009)

1056-57-1255 **Loretta Bartolini*** (bartolini@math.okstate.edu), Department of Mathematics, Oklahoma State University, 401 Mathematical Sciences, Stillwater, OK 74078. *One-sided Heegaard splittings of 3-manifolds.*

While two-sided Heegaard splittings are well known and understood in 3-manifold topology, their one-sided counterpart is much less common. Rather than splitting a manifold along an orientable surface to get a pair of handlebodies, a one-sided splitting cuts along an embedded non-orientable surface to yield a single handlebody.

Until recently, little has been known about such splittings, with standard two-sided techniques and results not being directly applicable. We will discuss the context and distinguishing behaviour of one-sided splittings, along with recent results in the area. (Received September 21, 2009)

1056-57-1313 **P. Robert Kotiuga*** (prk@bu.edu), Boston University, ECE Dept., 8 Saint Mary's Street, Boston, MA 02215. *A dictionary for defining key concepts in plasma Physics in terms of Clebsch charts in contact geometry.* Preliminary report.

Terms like "tubes and slices", which go back to Faraday and Maxwell, as well as more modern terms like "magnetic surfaces" and "reconnection points" are used extensively to describe three-dimensional vector fields in plasma physics. These terms can be rigorously defined in terms of differential forms and foliations with singularities, without reference to the underlying metric. In 3-d, this brings the Clebsch charts of contact geometry to the fore. Although this could have been anticipated by J. C. Maxwell and A. Clebsch, it is now important to develop this dictionary in a rigorous manner since recent results concerning foliations, confoliations, open book decompositions, and (over)twisted contact structures are then easily related to the (near-)force-free magnetic fields encountered in plasma physics. This in turn enables one to obtain rigorous topological characterizations of plasma equilibria with a minimum of assumptions about the mathematical model used to model the underlying physics processes. Some ties to "fillings of contact structures" and Heegaard-Floer homology will also be exposed. (Received September 21, 2009)

1056-57-1329 **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. (Received September 21, 2009)

1056-57-1373 **Abhijit Champanerkar*** (abhijit@math.csi.cuny.edu), Department of Mathematics, College of Staten Island, CUNY, 2800 Victory Boulevard, Staten Island, NY 10314, and **Ilya Kofman** (ikofman@math.csi.cuny.edu), Department of Mathematics, College of Staten Island, CUNY, 2800 Victory Boulevard, Staten Island, NY 10314. *On Jones polynomials of closed braids with a full twist.* Preliminary report.

Let $L$ be a closed $n$–braid with a full positive twist, and with up to $n$ negative crossings. We show that the Jones polynomial of $L$ satisfies a braid index constraint, which is a gap between the first two non-zero coefficients of $(1-t^2)\cdot V_L(t)$. (Received September 21, 2009)

1056-57-1436 **Neal W. Stoltzfus*** (stoltz@math.lsu.edu), Dept. Math., Louisiana State University, Baton Rouge, LA 70803, and **Brittan Farmer**, Dept. Math., 2074 East Hall, University of Michigan, Ann Arbor, MI 48109-1043. *Ribbon-graph tensor products, relative polynomial invariants and applications to links.* Preliminary report.

This is a preliminary report on the behavior of the Bollobas-Riordan-Whitney-Tutte polynomial of ribbon graphs under the operations of 2-sums and tensor product. Our approach uses a generalization of the 3-variable pointed Tutte polynomial of Las Vergnas to a 5-variable invariant of pointed ribbon graphs. Applications are made to the Jones polynomials of k-fold parallels. (Received September 21, 2009)

1056-57-1573 **Moshe Cohen*** (moshe@math.lsu.edu), Department of Mathematics, Louisiana State University, 303 Lockett Hall, Baton Rouge, LA 70803, and **Oliver Dasbach** and **Heather M. Russell**. *New twisted dimer model for the twisted Alexander polynomial.* Preliminary report.

One can "twist" the Alexander polynomial by incorporating information coming from representations of the fundamental group of a link complement. One familiar representation is encoded by knot colorings. We generalize the dimer model for the Alexander polynomial to a twisted version with a more complicated structure and discuss properties of the polynomials that arise in this context. (Received September 22, 2009)

1056-57-1652 **Mark H. Meilstrup*** (mark@math.byu.edu), BYU Mathematics Deptartment, 292 TMCB, Provo, UT 84602, and **Gregory Conner** and **Dusan Repovs**. *Fundamental Groups of Solenoid Complements.*

A solenoid is a compact connected topological group that is an inverse limit of circles. When a solenoid is embedded in three space, its complement is an open three manifold. We discuss the fundamental groups of such manifolds, and show that the complements of different solenoids (arising from different inverse limits) have different fundamental groups. Also, embeddings of the same solenoid can give different groups; in particular, the nicest embeddings are unknotted at each level, and give an Abelian fundamental group, while other embeddings have non-Abelian groups. (Received September 22, 2009)

1056-57-1710 **Ilya Kofman*** (ikofman@math.csi.cuny.edu), Department of Mathematics, 1S, College of Staten Island, 2800 Victory Boulevard, New York, NY 10314. *Geometry of Lorenz knots.*

Lorenz knots are periodic orbits in the flow on $R^3$ given by the Lorenz differential equations. Birman and Kofman identified over half of the simplest hyperbolic knots as Lorenz knots. We will discuss the geometry of hyperbolic Lorenz knot complements. (Received September 22, 2009)

1056-57-1742 **Ryan Derby-Talbot*** (rdt@questu.ca), Quest University Canada, 3200 University Boulevard, Squamish, BC V8N0B8, Canada. *Surfaces in generic toroidal 3-manifolds.*

Understanding how tori embed in 3-manifolds has played a crucial role in addressing the classification problem for 3-manifolds. For example, the proof of Thurston's Geometrization Conjecture establishes that every irreducible, orientable 3-manifold has a canonical collection of embedded tori that separate the manifold into geometrizable pieces, these pieces being collectively called the characteristic submanifold. In this talk, we will discuss how the topology of a "generic" orientable 3-manifold is reflected by the topology of its characteristic submanifold. In particular, if a 3-manifold is formed via complicated gluings of its characteric submanifold along the gluing tori, then every low index (incompressible or strongly irreducible) surface in the 3-manifold comes from such a surface in the characteristic submanifold. (Received September 22, 2009)

1056-57-1825 **David Futer**, **Efstratia Kalfagianni** and **Jessica S Purcell*** (jpurcell@math.byu.edu), Mathematics Department, Brigham Young University, Provo, UT 84602. *Adequate knots, guts, and volumes I: surfaces and polyhedra.*

In these talks (parts I and II) we describe recent progress on a project to relate the Jones polynomial of a knot to geometric invariants of the knot complement. More specifically, we explore relations between the Jones polynomial, the hyperbolic volume of the knot complement, and the topology of certain surfaces spanned by the knot (state surfaces). In part I, we describe how a diagram of a knot (which is "adequate" but not necessarily alternating) guides a natural decomposition of the knot complement into polyhedra with some nice properties. One pleasant property is that a certain incompressible surface with the knot as boundary shows up among the walls of the polyhedra. (Received September 22, 2009)

1056-57-1827 **Moshe Cohen**, **Oliver Dasbach** and **Heather M. Russell*** (hrussell@math.lsu.edu). *A dimer model for the twisted Alexander polynomial.*

The dimer model is the study of the set of all perfect matchings of a graph. By examining a certain bipartite graph associated to a knot, the dimer model provides a method for calculating the Alexander polynomial. In this work we generalize this idea to give a new combinatorial way to calculate the twisted Alexander polynomial. We discuss properties and applications of this approach. (Received September 22, 2009)

1056-57-1875 **Rena MH Levitt*** (rena.levitt@pomona.edu), Department of Mathematics, 610 North College Avenue, Claremont, CA 91711. *The Structure of Combinatorial Geodesics in $CAT(0)$ Simplicial 3-Complexes.*

In a simplicial complex, the combinatorial metric on the 0-skeleton is defined by taking the distance between vertices $v$ and $w$ to be the minimum length of edge paths in the between them. Paths of minimal length are combinatorial geodesics. In this talk, I will discuss the structure of combinatorial geodesics in $CAT(0)$, simplicial 3-complexes and use this structure to give a metric proof of the following theorem; groups acting geometrically on $CAT(0)$, simplicial 3-complexes are biautomatic, a condition that gives a positive solution to both the word problem and the conjugacy problem for these groups. (Received September 22, 2009)

1056-57-1913 **David Futer*** (dfuter@temple.edu), Mathematics Department, Temple University, Philadelphia, PA 19122, and **Efstratia Kalfagianni** and **Jessica S Purcell**. *Adequate knots, guts, and volumes II: volume and Jones polynomial.*

In these talks (parts I and II) we describe recent progress on a project to relate the Jones polynomial of a knot to geometric invariants of the knot complement. More specifically, we explore relations between the Jones polynomial, the hyperbolic volume of the knot complement, and the topology of certain surfaces spanned by the knot (state surfaces). In part II, we describe how the combinatorial structure of the polyhedral decomposition from part I relates coefficients of the Jones polynomial to the *guts* of the incompressible surface. It follows, by work of Agol, Storm, and Thurston, that coefficients of the Jones polynomial provide a lower bound for the volume of the knot. (Received September 22, 2009)

1056-57-1944 **Jeffrey Boerner*** (jboerner@math.uiowa.edu), 14 MacLean Hall, Iowa City, IA 52245. *The Kauffman bracket skein module of $T^3$.*

The Kauffman bracket skein module of a 3-manifold is the module of isotopy classes of framed links embedded in the 3-manifold, subject to the Kauffman bracket skein relation. Often these skein modules can be difficult to compute. Dabkowski and Mroczkowski computed the Kauffman bracket skein module of the twice punctured disk cross $S^1$. I will build on their notation and methods to explore the Kauffman bracket skein module of $T^3$. (Received September 22, 2009)

# 58 ► Global analysis, analysis on manifolds

1056-58-49 **Carolyn S Gordon*** (csgordon@dartmouth.edu), Department of Mathematics, 6188 Kemeny Hall, Dartmouth College, Hanover, NH 03755. *You can't hear the shape of a manifold.*

Inverse spectral problems ask how much information about an object is encoded in spectral data. For example, Mark Kac's question "Can you hear the shape of a drum?" asks whether a plane domain, viewed as a vibrating membrane, is determined by the Dirichlet eigenvalue spectrum of the associated Laplacian, equivalently, by the characteristic frequencies of vibration. The lecture will focus on Kac's question and its generalization to Riemannian manifolds. We will consider methods for constructing manifolds with the same spectral data and compare examples of such "sound-alike" manifolds. We will also refer to related constructions on discrete and quantum graphs. (Received September 16, 2009)

1056-58-92 **Daniel Freeman**, **Daniel Poore**, **A. Rebecca Wei*** (arw27@case.edu) and **Madeline Wyse** (mkw02007@mymail.pomona.edu). *Continuous Frames on Manifolds.* Preliminary report.

Continuous moving bases on manifolds play important roles in such areas as differential geometry and mathematical physics. However, not all manifolds have a continuous moving basis for their tangent space. Some important examples of non-parallelizable manifolds are the 2-sphere, Mobius strip, Klein bottle, and projective plane. We show that all of these examples have natural continuous moving Parseval frames of 3 vectors. A Parseval frame can be thought of as a spanning set that can decompose and reconstruct vectors in a similar manner to a basis. Hence, continuous moving Parseval frames offer a basis-like structure for non-parallelizable manifolds. We also examine continuous dilations of continuous moving Parseval frames. It is an important result in frame theory that every Parseval frame can be dilated to an orthonormal basis. However, due to topological obstructions, a full generalization of this result is impossible for continuous moving Parseval frames. We prove instead that every continuous moving Parseval frame can be continuously dilated to an orthonormal set. Using this result, we show that every manifold with a continuous moving Parseval frame can be embedded in a parallelizable manifold such that the Parseval frame is the projection of a basis for the larger manifold. (Received July 25, 2009)

1056-58-525 **Jeffrey McGowan*** (mcgowan@ccsu.edu), Central Connecticut State University, Dept of Mathematics, 1615 Stanley Street, New Britain, CT 06050, and **Eran Makover** (makover@gmail.com), Central Connecticut State University, Dept. of Mathematics, New Britain, CT 06033. *The fundamental domain of Random Riemann surfaces.*

We investigate relations between cubic graphs and Riemann surfaces that are constructed from a random choice of a graph and orientation. Our goal is to describe the global geometry of such a "typical" Riemann Surface. This model of constructing surfaces from graphs enables us to study properties like the Cheeger constant, systole length, and the size of embedded balls in large genus surfaces by examining random cubic graphs. (Received September 11, 2009)

1056-58-527 **Eran Makover*** (makovere@ccsu.edu), Department of Mathematical Sciences, Central Connecticut State University, 1615 Stanley Street, New Britain, CT 06050, and **Jeff McGowan**, CT. *The fundamental domain of Random Riemann surfaces.*

We investigate relations between the cubic graphs and Riemann surfaces that are constructed from a random choice of a graph and orientation. Our goal is to describe that global geometry of a "typical" Riemann Surfaces. This model of constructing surfaces from graphs enables us to study properties like the Cheeger constant, systole length, and the size of embedded balls in large genus surfaces by examining random cubic graphs. (Received September 11, 2009)

1056-58-869 **Julie Rowlett*** (rowlett@math.uni-bonn.de), Hausdorff Center for Mathematics, Villa Maria Endenicher Allee 62, 53115 Bonn, Germany. *Spectral problems for polygons.*

This talk focuses on some spectral problems for polygons, and triangles in particular. We will discuss recent progress with Z. Lu on the fundamental gap conjecture for triangles and related open questions whose statements are pleasantly simple. For example,

*Can one hear the shape of a triangle with a "real" ear?*

–Chang, DeTurck, Lu

In conclusion, we will discuss some open extremal spectral problems for polygons and offer ideas. (Received September 18, 2009)

1056-58-919 **Emily Proctor*** (eproctor@middlebury.edu) and **Elizabeth Stanhope** (stanhope@lclark.edu). *Spectral and geometric bounds on orbifold homotopy type.* Preliminary report.

Consider an isospectral set of Riemannian orbifolds with sectional curvature bounded below. In this talk, I will describe our work to prove that such a set contains orbifolds of only finitely many orbifold category homotopy types. A previous result by Stanhope shows that the spectral bounds can be replaced with bounds on diameter and volume. From there our work is to generalize a similar result for manifolds by Grove and Petersen. (Received September 18, 2009)

1056-58-1112 **David Borthwick** (davidb@mathcs.emory.edu), Dept. of Mathematics and Computer Science, Emory University, Atlanta, GA 30322, and **Peter A. Perry*** (perry@ms.uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40506-0027. *Inverse scattering results for manifolds hyperbolic at infinity.*

This is joint work with David Borthwick. We study the inverse resonance problem for conformally compact manifolds which are hyperbolic outside a compact set. Our results include compactness of isoresonant metrics in dimension two and of isophasal negatively curved metrics in dimension three. In dimensions four or higher we prove topological finiteness theorems under the negative curvature assumption. (Received September 20, 2009)

1056-58-1289 **Alejandro Uribe*** (uribe@umich.edu), Department of Mathematics, 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109-1043. *Some applications of the trace formula on orbifolds to the inverse spectral problem.* Preliminary report.

I will discuss some applications of the trace formula on orbifolds to the inverse spectral problem. (Received September 21, 2009)

1056-58-1299 **Emily B. Dryden*** (emily.dryden@bucknell.edu), Department of Mathematics, Bucknell University, Lewisburg, PA 17837, and **Victor Guillemin** and **Rosa Sena-Dias**. *Hearing Delzant polygons from the equivariant spectrum.*

Can one hear the moment polytope of a toric manifold? Motivated by this question of Miguel Abreu, we ask whether the equivariant spectrum of the Laplacian acting on smooth functions on a toric manifold determines the moment polytope associated to the manifold. Heat invariant techniques, combined with combinatorial and geometric arguments, allow us to prove the desired result for Delzant polygons. (Received September 21, 2009)

1056-58-1811 **David Richeson*** (richesod@dickinson.edu), Department of Mathematics and Comp. Sci., Dickinson College, Carlisle, PA 17013, and **Jim Wiseman**. *Symbolic Dynamics for Nonhyperbolic Systems.*

We introduce index systems, a tool for studying isolated invariant sets of dynamical systems that are not necessarily hyperbolic. The mapping of the index systems mimics the expansion and contraction of hyperbolic maps on the tangent space, and they may be used like Markov partitions to generate symbolic dynamics. Every continuous dynamical system satisfying a weak form of expansiveness possesses an index system. Because of their topological robustness, they can be used to obtain rigorous results from computer approximations of a dynamical system. (Received September 22, 2009)

1056-58-1965 **John Luecke*** (luecke@math.utexas.edu), University of Texas at Austin, Mathematics Department, 1 University Station C1200, Austin, TX 78712-0257, and **Isabel Darcy** and **Mariel Vazquez**. *Analysis of difference topology experiments on a Protein-DNA complex.*

Biologists Pathania, Jayaram, and Harshey developed an experimental technique, difference topology, for analyzing the structure of a protein-DNA complex, the mu transpososome. Deducing the shape of the complex from the experimental results presents an interesting knot theoretic problem. In particular, the three strands of DNA in the complex are thought of as a 3-string tangle in a ball, and we seek those tangles consistent with the experimental results. We characterize such "solution tangles" by certain knotted graphs. By investigating planarity conditions on these graphs, we show that the only rational tangle solution, and the only solution with small crossing number, is that deduced by Pathania, Jayaram, and Harshey. That is, though there are other possible solutions, there is a unique one that is biologically relevant. (Received September 22, 2009)

1056-58-2036 **Martin Ehler*** (ehlermar@math.umd.edu), Department of Mathematics, Mathematics Building, University of Maryland, College Park, MD 20742-4015, and **Wojciech Czaja** (wojtek@math.umd.edu), Mathematics Building, Department of Mathematics, University of Maryland, College Park, MD 20742-4015. *Schroedinger-Type Eigenmaps for the Analysis and Classification of Multispectral Data in Bio-Medical Imaging.*

We introduce a barrier potential for Schroedinger operators on a graph and discuss its use in the field of manifold recovery if a priori knowledge is available. The information content of high-dimensional data is often much lower than the dimension, and the data lies on a manifold that must be recovered. State-of-the-art dimension reduction and manifold recovery methods like Diffusion Maps, Diffusion Wavelets, Locally Linear Embedding, and Laplacian Eigenmaps are kernel-based and rely on spectral graph theory. These methods, however, are fully automated, which restrains the use of a priori knowledge about the manifold.

Based on the Laplacian kernel, we introduce a flexible barrier potential, that can capture additional labels, and obtain a Schroedinger type kernel. The result is a new Schroedinger Eigenmaps method that allows for input in an otherwise fully automated dimension reduction process.

This new tool is applied to multispectral fluorescence images of National Eye Institute study patients with retinal pathology, but could be usefully applied to a wide range of classification problems. (Received September 22, 2009)

# 60 ► Probability theory and stochastic processes

1056-60-14 **Richard W Kenyon***, Mathematics Department, Brown University. *Laplacians on vector bundles on graphs.*

The uniform spanning tree (UST) on a graph is a basic model in discrete probability, with connections to loop-erased random walk, determinantal processes and SLE.

The UST on $\mathbb{Z}^2$ has a beautiful conformally invariant scaling limit (limit when the mesh size tends to zero), in which one can find simultaneously a number of different conformally invariant objects, e.g. $SLE_2$, $SLE_8$, and the Gaussian free field.

The classical matrix-tree theorem relates the determinant of the combinatorial laplacian on a graph to the number of spanning trees. We generalize this result to laplacians on vector bundles, giving a combinatorial interpretation of their determinants.

This generalization allows us to study spanning trees and forests on not just planar graphs but graphs embedded on surfaces, and in particular to construct scaling limits of spanning trees on Riemann surfaces. (Received September 22, 2009)

1056-60-38 **John R Kerl*** (kerl@math.arizona.edu), 617 N. Santa Rita Ave., P.O. Box 210089, Tucson, AZ 85711. *MCMC methods for spatial random permutations.* Preliminary report.

Models of random spatial permutations arise in the study of Bose-Einstein condensation. Namely, permutations of sites occur with probabilities depending on lengths of permutation jumps, as well as on interactions between jumps. Below a critical temperature, one observes the onset of long permutation cycles in spite of short-distance permutation-jump interactions. Following work of Betz, Ueltschi, Gandolfo, and Ruiz, we present conjectures for some of these models on the cubic unit lattice, along with results obtained by Markov chain Monte Carlo simulations and finite-size scaling. These conjectures include the shift in critical temperature as a function of interaction strength, and statistics of maximum cycle length in comparison to uniform random permutations. We compare our findings to analytical results which are known for related models. (Received July 07, 2009)

1056-60-91 **Christopher P Calderon*** (calderon@rice.edu), Lawrence Berkeley National Lab, 1 Cyclotron Rd, Berkeley, CA 94720. *Extracting multiscale information from time series characterizing nanoscale systems.*

Single-molecule experiments and computer simulations have generated noisy data sets containing useful information about the dynamics of nanoscale systems. The many degrees of freedom present and multiple time-scale fluctuations inherent at this level of detail complicate the task of summarizing the interesting information in these data sets. I demonstrate how a collection of surrogate processes, estimated from batches of time series

using new local maximum likelihood techniques, can assist in understanding these complex data sets . Both thermodynamic and kinetic information can be extracted using the collection of surrogate models. The methods are also useful when a good set of system observables is unknown or not experimentally accessible. For example, a collection of surrogate models can be used to infer information about slowly evolving degrees of freedom not directly monitored. Illustrative results obtained using various all-atom molecular dynamics simulations and atomic force microscope experiments are presented. I also discuss new penalized spline algorithms that were developed to address the ill-conditioned design matrices that can result when modeling the single-molecule time series data and outline future applications/extensions of the algorithms developed. (Received July 25, 2009)

1056-60-135 **Mark A McKIbben*** (mmckibben@goucher.edu), Goucher College, Mathematics and Computer Science Department, 122 Hoffberger Science, Baltimore, MD 21204. *Abstract Measure-Dependent Stochastic Evolution Equations in a Hilbert Space with Applications to Nonlinear Diffusion.* Preliminary report.

A class of abstract stochastic evolution equations of Ito-type in a separable Hilbert space is investigated. The evolution equations under consideration are characterized by dependence of the nonlinearity on the probability distribution of the state process. Such equations are of so-called McKean-Vlasov type and arise naturally in the mathematical modeling of nonlinear diffusion processes.

A brief survey of past work on this type of equation will be provided, followed by a discussion of existence and stability theory for such a class of equations undergoing time-delays and impulsive effects. The abstract results will be illustrated by applications to concrete initial-boundary value problems of various kinds. Several open problems will also be mentioned. (Received July 30, 2009)

1056-60-452 **John C Wierman*** (wierman@jhu.edu), Dept. of Applied Mathematics and Statistics, 100 Whitehead Hall, Johns Hopkins University, Baltimore, MD 21218. *Self-dual planar hypergraphs and exact bond percolation thresholds.* Preliminary report.

A generalized star-triangle transformation and a concept of triangle-duality have been introduced recently in the physics literature to predict exact percolation threshold values of several lattices. We investigate the mathematical conditions for the solution of bond percolation models, and identify an infinite class of lattice graphs for which exact bond percolation thresholds may be rigorously determined as the solution of a polynomial equation. This class is naturally described in terms of hypergraphs, leading to definitions of planar hypergraphs and self-dual planar hypergraphs. We show that there exist infinitely many self-dual planar 3-uniform hypergraphs, and, as a consequence, that there exist infinitely many real numbers $a \in [0, 1]$ for which there are infinitely many lattices that have bond percolation threshold equal to $a$. (Received September 18, 2009)

1056-60-471 **Ira Gerhardt*** (ira.gerhardt@manhattan.edu), Dept. of Mathematics and Computer Science, 4513 Manhattan College Parkway, Riverdale, NY 10471, and **Barry L. Nelson** (nelsonb@northwestern.edu). *Characterizing departure count moments from queueing nodes fed by nonstationary, non-Poisson arrival processes.*

Many real-world systems are modeled as networks of nonstationary queueing nodes in an effort to approximate time-dependent congestion measures such as the mean and variance of the queue length at each node. An important step in providing these approximations lies in properly characterizing the nonstationary traffic flow within the network; however, this may prove to be difficult, particularly when the external arrival processes feeding the network are non-Poisson. We provide techniques for calculating moments of the departure count for nodes whose arrival processes are nonstationary and non-Poisson; specifically, we derive a finite-system of differential equations that describe the instantaneous rate of change of the time-dependent moments of the departure counting process from each node in the network. We compare our numerical approximation to simulation models, and find our results satisfactory. (Received September 09, 2009)

1056-60-507 **S. S. Sritharan*** (sssritha@nps.edu), Graduate School of Engineering and Applied Sc, Naval Postgraduate School, Monterey, CA 93943. *Stochastic Analysis, Control and Nonlinear Filtering of Fluid Dynamic Models.*

We will present some recent results on nonlinear filtering and control of Navier-Stokes equations as well as some vortex dynamics models subjected to Gaussian and Levy type noise. Some of the main results are uniqueness proof of FKK and Zakai equations for filtering, convergence of particle filtering methods and solvability of Hamilton-Jacobi-Bellman equation for feedback control. (Received September 10, 2009)

1056-60-549 **Michael Powers**, **Wei-Shi Yang** and **Sheng Xiong*** (sheng@temple.edu), Department of Mathematics, Temple University, 1805 North Broad St., Philadelphia, PA 19122.
*Lanchester SDEs and the probability of the target destruction — a stochastic model of terrorism risk.* Preliminary report.

In this study, we propose a system of Lanchester stochastic differential equations

$$\begin{cases} dp = -k_1 q^{\alpha} dt + \sigma_1(p,q)\, dZ_1(t) \\ dq = -k_2 p^{\beta} dt + \sigma_2(p,q)\, dZ_2(t) \end{cases}$$

to model the terrorism war between the attackers $p$ and the defenders $q$. We investigate the ruin probability and the probability of win of either side by using martingale approach. Our result shows that the ruin occurs almost surely, and for fixed size of attackers, the probability of the target destruction exponentially decays as the size of the defenders approaches infinity. We also explore the possible applications of these results from the insurance perspective. (Received September 11, 2009)

1056-60-581 **Santanu Chakraborty*** (schakraborty@utpa.edu), Department of Mathematics, University of Texas - Pan American, 1201 West University Drive, Edinburg, TX.
*Completely Simple Semigroups of Real d x d Matrices and Recurrent Random Walks.*

The structure of d x d nonnegative idempotent matrices and d x d real idempotent matrices were obtained in Mukherjea's paper about 23 years ago (1986). Then, Mukherjea, also had given the structure of completely simple semigroup of d x d nonnegative matrices around the same time. Recently, we have given a unique structure of real d x d idempotent matrices and used it to obtain the structure of completely simple semigroup of d x d real matrices. In this talk, we describe this structure and also show how this can be used to find the algebraic structure of the set of recurrent states of certain random walks in d x d real matrices. (Received September 13, 2009)

1056-60-590 **George Yin** and **Jie Yu*** (jyu@roosevelt.edu), 1400 N. Roosevelt Blvd, Schaumburg, IL 60173, and **Qing Zhang**. *A Stochastic Approximation Algorithm for Option Pricing Model Calibration with a Switchable Market.*

This paper is concerned with option pricing under a regime switching model. The switching process takes two different modes, and the underlying stock price evolves in accordance with the two modes dictated by a continuous-time, finite-state Markov chain. At any given instance, the price follows either a geometric Brownian motion model or a mean-reversion model depending on its market mode. Stochastic approximation/optimization algorithms are developed for model calibration. Convergence of the algorithm is proved; rate of convergence is also provided. Option market data are used to predict future market mode. (Received September 14, 2009)

1056-60-670 **Yumin Wang*** (yumin@math.wayne.edu), Department of Mathematics, Wayne State University, 1150 Faculty/Administration BLdg (FAB), Detroit, MI 48202. *Quantile Hedging for Guaranteed Minimum Death Benefits.* Preliminary report.

Quantile hedging for contingent claims is an active topic of research in mathematical finance. It play a 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, except in the limit as the number of contracts becomes infinitely large. In this article, we apply ideas from finance to derive quantile hedges for these products under various assumptions. (Received September 15, 2009)

1056-60-758 **Qiang Zhen*** (qzhen2@uic.edu), Dept. of Math., Stat. and Comp. Sci., University of Illinois at Chicago, 851 S Morgan St, SEO 322, Chicago, IL 60607, and **Charles Knessl**.
*On Sojourn Times in the Finite Capacity $M/M/1$ Queue with Processor Sharing.*

We consider a processor shared $M/M/1$ queue that can accommodate at most a finite number $K$ of customers. We give an exact expression for the sojourn time distribution in this finite capacity model in terms of a Laplace transform by using the discrete Green's function. We then give the tail behavior, for the limit $K \to \infty$, by locating the dominant singularity of the Laplace transform. The asymptotic derivation is under three scales of the traffic intensity $\rho$, which are $\rho - 1 = O(K^{-1})$; $\rho - 1 = bK^{-1/2}$, $b > 0$ and $\rho > 1$. (Received September 16, 2009)

1056-60-785 **Michael J.J. Barry*** (mbarry@allegheny.edu), Department of Mathematics, Allegheny College, 520 N. Main St., Meadville, PA 16335. *The Density Function of the First Occurrence of a Binary Pattern.*

The probability density function associated with the first occurrence of a binary pattern in a sequence of independent Bernoulli trials was given in McDermott and Sheahan in *The Distribution of First Occurrence of Patterns* *of Outcomes of Bernoulli Experiments*, Mathematical Proceedings of the Royal Irish Academy **104A**(1)(2004), 1–15. We give a simpler expression for it in terms of a unique family of homogeneous polynomials in two variables. In the process, we obtain a recurrence relation for the density function and we study the coefficients of the homogeneous polynomials. (Received September 17, 2009)

1056-60-804 **Jef Caers*** (jcaers@stanford.edu), Energy Resources Engineering Dept, 367 Panama St, Stanford, CA 94305-2220. *Managing the Earth: Modeling Data into Decisions under Geological and Engineering Uncertainty.*

Critical to managing the Earth is managing the lack of information available when making decisions in engineering projects. Decisions need to made in the face of geological and engineering uncertainty. Currently, only partial solutions exist. Earth modeling tools such as geostatistics can model the spatial variation of key variables in great detail constrained to data. Management science and engineering provides methodologies for optimizing systems that address risk when uncertainty is present. However, these methods have been developed for systems that are well-controlled, are sampled at high frequency and do not account for the complex media considered in Earth Science applications as well as the sparse sampling.

I will outline new methods that marry both the engineering control and decision framework with state-of-the-art Earth modeling tools and show an application to the value of information calculation of gathering geophysical data in a groundwater decision framework. The key idea behind these methods is to formulate a distance between any two models created by Earth modeling tools and make this distance dependent on the particular decision at hand. I show that this seamlessly integrates the modeling process from data to decision. (Received September 17, 2009)

1056-60-980 **Kumer Pial Das*** (kumer.das@lamar.edu), 7930 Buttercup Lane, Beaumont, TX 77713. *A Stochastic Approach to the Bonus-Malus System.* Preliminary report.

Bonus-Malus system, under certain conditions, can be interpreted as a Markov chain whose n-step transition probabilities converge to a limit probability function. The goal of this study is to find and investigate the stationary distribution of three Bonus-Malus system used worldwide. (Received September 19, 2009)

1056-60-981 **Cristina Tone*** (crtone@indiana.edu), Indiana University, Department of Mathematics, 831 East 3rd St, Bloomington, IN 47405. *Central Limit Theorems for Hilbert-space Valued Random Fields Satisfying a Strong Mixing Condition.*

We want to study the asymptotic normality of the normalized partial sum of a strictly stationary Hilbert-space valued random field satisfying a strong mixing condition. We proceed by first proving a central limit theorem for a $\rho'$-mixing strictly stationary random field of real-valued random variables. Next, we extend the real-valued case to a strictly stationary random field of m-dimensional random vectors satisfying the same conditions. Finally, we extend the finite-dimensional case to an (infinite-dimensional) Hilbert space-valued random field satisfying the $\rho'$-mixing condition. (Received September 19, 2009)

1056-60-1068 **Mark L Huber*** (mhuber@cmc.edu), Dept. of Mathematics and Computer Science, Claremont McKenna College, 850 Columbia Avenue, Claremont, CA 91711. *Spatial Birth-Death-Swap Chains.*

Markov chains have long been used for generating random variates from spatial point processes. Broadly speaking, these chains fall into two categories: Metropolis-Hastings type chains running in discrete time and spatial birth death chains running in continuous time. These birth death chains only allow for removal of a point or addition of a point. In this work it is shown that the addition of transitions where a point is moved from one location to the other can aid in shortening the mixing time of the chain. Here the mixing time of the chain is analyzed through coupling, and use of the swap moves allows for analysis of a broader class of chains. Furthermore, these swap moves can be employed in perfect sampling algorithms via the dominated Coupling from the Past procedure of Kendall and Møller. This method can be applied to any pairwise interaction model with repulsion. In particular, an application to the Strauss process is developed in detail, and the swap chains are shown to be much faster than standard birth death chains. (Received September 20, 2009)

1056-60-1080 **Matthew R.A. Sedlock*** (msed84@jhu.edu), 3400 N. Charles St., 100 Whitehead Hall, Baltimore, MD 21218, and **John C. Wierman** (wierman@jhu.edu), 3400 N. Charles St., 100 Whitehead Hall, Baltimore, MD 21218. *A method for finding exact site percolation critical thresholds for a class of lattices.* Preliminary report.

Using a generalized version of the star-triangle transformation, a method was recently developed to determine the exact bond percolation critical thresholds for lattices in a certain class. By a bond-to-site transformation, the result extends to finding exact site percolation critical thresholds for the line lattices of lattices in the class. We view the problem from the site percolation perspective and identify a method to find the exact site percolation critical threshold for lattices with certain properties. This allows us to solve for the site percolation critical thresholds for lattices not arising as line lattices of bond models, thereby generalizing the bond model results. (Received September 20, 2009)

1056-60-1123 **Son Luu Nguyen*** (luu@math.wayne.edu), 1138 Faculty/Administration Building, 656 W Kirby, Detroit, MI 48202, and **George Gang Yin** (gyin@math.wayne.edu), 1217 Faculty/Administration Building, 656 W Kirby, Detroit, MI 48202. *Strong Approximation for Markov Modulated Random Sequences with Two-Time Scales.*

This talk is concerned with asymptotic properties of Markov modulated random processes having two-time scales. The model contains a number of mixing sequences modulated by a switching processes that is a discrete-time Markov chain. The motivation of our study stems from applications in manufacturing and production planning, communication networks, and economic systems. One of the main features is the inclusion of regime-switching processes to model random environment and other random factors. Our main effort focuses on obtaining a strong approximation result. An example for a stochastic optimization problem is also provided. (Received September 21, 2009)

1056-60-1167 **Suman Sanyal*** (sanyal@marshall.edu), Smith Hall 743C, Department of Mathematics, Marshall University, Huntington, WV 25755. *Global Stability of Complex-Valued Neural Networks on Time Scales.*

In this talk, we will analyze the activation dynamics of complex-valued neural networks on general time scales. Besides presenting conditions guaranteeing the existence of a unique equilibrium pattern, its global exponential stability is discussed. Some numerical examples for different time scales are given in order to highlight the results. (Received September 21, 2009)

1056-60-1253 **Bala Rajaratnam*** (brajarat@stanford.edu), Department of Statistics - Sequoia Hall, 390 Serra Mall, Stanford University, Stanford, CA 94305-4065. *Markov Chains, Generalized Wishart distributions and Applications to High Dimensional Statistical Inference.*

Covariance graph models are an important class of models in high dimensional statistics. These models are used to encode marginal independence among variables by means of a graph, and give rise to curved exponential families. A satisfactory framework for Bayesian inference for this class of models in high dimensions is not available in the literature. We propose a rich family of generalized Wishart distributions, carefully constructed on appropriate parameter spaces, which act as a conjugate family of priors for Bayesian analysis of Gaussian covariance graph models. Our generalized Wishart distributions naturally lead to a study of Markov chains. By examining the appropriate conditional distributions for our class of these generalized Wishart distributions, we derive a block Gibbs sampling procedure to sample from these distributions. We then proceed to rigorously prove convergence of the block Gibbs sampler. We also present various useful theoretical properties of this class of distributions, including the so-called hyper Markov properties, which enable Bayesian inference in high dimensions. We also explore the use of the theory developed above in practical settings.(This is joint work with Kshitij Khare) (Received September 21, 2009)

1056-60-1340 **Suman Sanyal*** (sanyal@marshall.edu), Smith Hall 743C, Department of Mathematics, Marshall University, Huntington, WV 25755. *Brownian motion indexed by a time scale and its applications.*

In this talk, we will present a generalized version of Wiener's existence result for one-dimensional Brownian motion by constructing a suitable continuous stochastic process where the index set is a time scale (an arbitrary nonempty closed subset of the real numbers). We provide a construction of a countable dense subset of a time scale and use it prove a generalized version of the Kolmogorov-Ĉentsov theorem. As a corollary, we obtain a local Hölder-continuity result for the sample paths of the generalized Brownian motion on time scales. (Received September 21, 2009)

1056-60-1367 **Vladimir Pesic*** (vpesic@math.ucsd.edu) and **Ruth Williams** (williams@math.ucsd.edu), UCSD Department of Mathematics, 9500 Gilman Drive, La Jolla, CA 92093. *On Dynamic Scheduling of a Parallel Server System with Certain Graph Structure.* Preliminary report.

Assuming the server-buffer graph associated with a parallel server system has a certain structure, we give sufficient conditions for a least control process to be the optimal solution of the equivalent workload formulation of the approximating Brownian control problem. Under these conditions, we report on some preliminary analysis of a threshold-type policy that we conjecture is asymptotically optimal for the parallel server system. (Received September 21, 2009)

1056-60-1379 **Richard S Ellis**, **Jonathan Machta** and **Peter T Otto*** (potto@willamette.edu), Department of Mathematics, Willamette University, Salem, OR 97301. *Asymptotic behavior of the finite-size magnetization as a function of the speed of approach to criticality.*

The main focus of this paper is to determine whether the thermodynamic magnetization is a physically relevant estimator of the finite-size magnetization. This is done by comparing the asymptotic behaviors of these two quantities along parameter sequences converging to either a second-order point or the tricritical point in the mean-field Blume-Capel model. (Received September 21, 2009)

1056-60-1395 **Ben J Morris*** (morris@math.ucdavis.edu), Department of Mathematics, One Shields Ave, Davis, CA 95616. *Improved mixing time bounds for the Thorp shuffle.* Preliminary report.

The Thorp shuffle is defined as follows. Cut the deck into two equal piles. Drop the first card from the left pile or the right pile according to the outcome of a fair coin flip; then drop from the other pile. Continue this way until both piles are empty. We show that the mixing time for the Thorp shuffle with $2^d$ cards is $O(d^3)$. This improves on the best known bound of $O(d^4)$. (Received September 22, 2009)

1056-60-1404 **Ben J Morris*** (morris@math.ucdavis.edu), Department of Mathematics, One Shields Ave, Davis, CA 95616, and **Phillip Rogaway** and **Till Stegers**. *How to encipher small messages: Encryption using the Thorp shuffle.*

The Thorp shuffle is defined as follows. Cut the deck into two equal piles. Drop the first card from the left pile or the right pile according to the outcome of a fair coin flip; then drop from the other pile. Continue this way until both piles are empty. We analyze the Thorp shuffle and its application to a problem in cryptography. No prior knowledge of cryptography is assumed. Based on joint work with Phillip Rogaway and Till Stegers. (Received September 22, 2009)

1056-60-1408 **Nathan F. Ross*** (ross@stat.berkeley.edu), University of California, 367 Evans Hall #3860, Berkeley, CA 94720. *Using Reversible Markov Chains for Distributional Approximation.* Preliminary report.

Stein's method of exchangeable pairs is a well established tool for obtaining an error in the approximation of a probability distribution of interest by a well understood distribution (e.g. the normal or Poisson distribution). The usual way to apply the method is to construct a reversible Markov chain with a few key properties, the most important being that its stationary distribution is the measure of interest. From this point, the error in the approximation (which depends on the approximating distribution and the metric being used) can be obtained from some moment information related to the chain. We will briefly discuss the method in the context of normal approximation and then explain how it can be modified to obtain approximations to a discrete analog of the normal distribution in settings where a central limit theorem holds. (Received September 21, 2009)

1056-60-1744 **Ian Pierce*** (s-ipierce1@math.unl.edu), Department of Mathematics, Avery Hall 203, University of Nebraska, Lincoln, NE 68588. *Two related integrals over spaces of continuous functions, revisited.* Preliminary report.

In 1974, R.H. Cameron and D.A. Storvick published a paper that included theorems by means of which one can evaluate integrals of certain functionals on the two-parameter Yeh-Wiener space in terms of integrals of functionals on the ordinary single-parameter Wiener space. In the context of Cameron and Storvick's paper, we will discuss a theorem that extends some of their results and will consider applications and examples of this theorem. (Received September 22, 2009)

1056-60-1746 **James Allen Fill*** (jimfill@jhu.edu), The Johns Hopkins University, Dept. of Applied Mathematics and Statistics, 3400 N. Charles St., Baltimore, MD 21218-2682. *Hitting-time Distributions for Markov Chains.* Preliminary report.

I will discuss several representations of hitting-time distributions for (finite-state, ergodic, time-reversible, continuous-time) Markov chains and stochastic constructions corresponding to these representations. Examples of representations of distributions considered, each of which has a link to published work of Mark Brown, are those of

(i) the hitting time from state 0 of any given state for a birth-and-death chain on the nonnegative integers, as a convolution of exponential distributions;

(ii) the hitting time from stationarity of any given state, as a mixture of $N$-fold convolution powers of a certain distribution, with $N$ geometrically distributed; and

(iii) the hitting time from stationarity of any given set of states, as a convolution of certain modified-exponential distributions that relate to the interlacing eigenvalue theorem for bordered symmetric matrices.

Intertwinings of Markov semigroups (I'll explain what these are) play a key role in the stochastic constructions. (Received September 22, 2009)

1056-60-1836 **Partha Sarathi Dey*** (partha@stat.berkeley.edu), 367 Evans Hall, Department of Statistics #3860, Univ. of California at Berkeley, Berkeley, CA 94720. *Applicability of drift and minorization condition for finding rate of convergence of finite state space Markov chains.*

For Markov chains on general state space proving geometric ergodicity and finding an explicit rate of convergence to stationarity often require establishing a drift and an associated minorization condition. Also for finite state space Markov chain several well-established spectral methods are available. However, there is very little overlap between the methodologies for finding convergence rates for finite and general state space Markov chain. Here we will show that for finite state space Markov chain that makes only local transitions and have a "flat" stationary distribution, drift and minorization condition does not work well. It works only when the stationary distribution is peaked. On the other hand, methods from finite state space Markov chain can sometimes be used efficiently to get good convergence rate in general state space. This work arose out of a collaborative effort among participants of MRC conference on MCMC in summer 2009. (Received September 22, 2009)

1056-60-1920 **Srinivasan Balaji*** (balaji@gwu.edu), Department of Statistics, 2140 Pennsylvania Avenue NW, Washington, DC 20052, and **Hosam M Mahmoud** (hosam@gwu.edu), Department of Statistics, 2140 Pennsylvania Avenue NW, Washington, DC 20052. *Phases in the Mixing of Gases via the Ehrenfest Urn Model.*

The Ehrenfest urn is a model for the mixing of gases in two chambers. Classic research deals with this system as a Markovian model with a fixed number of balls, and derives the steady-state behavior as a binomial distribution (which can be approximated by a normal distribution). We study the gradual change for an urn containing $n$ balls from the initial condition to the steady state. We look at the status of the urn after $k_n$ draws. We identify three phases of $k_n$: The growing sublinear, the linear, and the superlinear. In the growing sublinear phase the amount of gas in either chamber is normally distributed, with parameters that are influenced by the initial conditions. In the linear phase a different normal distribution applies, in which the influence of the initial conditions is attenuated. The steady state is not a good approximation until a superlinear amount of time has elapsed. At the superlinear stage the mix is nearly perfect, with a nearly perfect symmetrical normal distribution in which the effect of the initial conditions is completely washed away. We give interpretations for how the results in different phases conjoin at the "seam lines." The Gaussian results are obtained via martingale theory. (Received September 22, 2009)

1056-60-1993 **Reid Andersen** and **Yuval Peres*** (peres@microsoft.com), 1 Microsoft Way, Redmond, WA 98052. *Finding Sparse Cuts Locally Using Evolving Sets.*

The connection between expansion properties of a graph and mixing time of a random walk on it is well known. "Evolving sets" are a set valued process that explains the connection probabilistically and allows use of size dependent expansion data. This process was analyzed by Morris and Peres (2003), and is related to the strong stationary duality analyzed in 1990 by Diaconis and Fill. We show how this process, first developed for theoretical purposes, yields an effective local partitioning algorithm that can identify a "community" for a given node in time that is proportional to the community size rather than the size of the whole graph. (Received September 22, 2009)

# *62 ► Statistics*

1056-62-59 **Anna E. Bargagliotti** (abargag@yahoo.com), Department of Mathematical Sciences, University of Memphis, Memphis, TN 38152, and **Raymond N. Greenwell*** (matrng@hofstra.edu), Department of Mathematics, 103 Hofstra University, Hempstead, NY 11549. *Further results on statistical significance of ranking paradoxes.* Preliminary report.

Haunsperger (2003) has shown that when the Kruskal-Wallis nonparametric statistical test is used to rank-order a list of alternatives, Simpson-like paradoxes arise, in which the individual parts give rise to a common decision, but the aggregate of those parts gives rise to a different decision. In a previous report, we investigated the statistical significance of the Kruskal-Wallis statistic for the differences in ranking when these paradoxes occur. Bargagliotti (2009) has shown that these paradoxes also arise using the Mann-Whitney and Bhapkar's $V$ test, so we extend our prior results to investigate the significance of these paradoxes. Our conclusion is that in the cases in which the paradoxes arise, the difference between the rankings of the candidates is not statistically significant. (Received July 23, 2009)

1056-62-329 **Dorin Drignei*** (drignei@oakland.edu), Mathematics and Statistics, Oakland University, Rochester, MI 48309. *Statistical Inference for Computer Models with Multidimensional Output.* Preliminary report.

A computer model, or code, is a computer implementation of a mathematical model underpinned by the physical properties of a phenomenon. Computer models are widely used in scientific investigations in order to gain a deeper understanding into the phenomenon studied. Here we propose new techniques for sensitivity analysis and calibration of expensive computer models with multidimensional output. An example involving vehicle Road Load Acquisition computer model and field data will be used to illustrate the methods. (Received August 29, 2009)

1056-62-423 **Maria Angelica Cueto**, **Jason Morton** and **Bernd Sturmfels*** (bernd@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94720. *Geometry of the Restricted Boltzmann Machine.*

The restricted Boltzmann machine is a graphical model for binary random variables. Based on a complete bipartite graph separating hidden and observed variables, it is the binary analog to the factor analysis model. We study this graphical model from the perspectives of algebraic statistics and tropical geometry, starting with the observation that its Zariski closure is a Hadamard power of the first secant variety of the Segre variety of projective lines. We derive a dimension formula for the tropicalized model, and we use it to show that the restricted Boltzmann machine is identifiable in many cases. Our methods include coding theory and geometry of linear threshold functions. (Received September 06, 2009)

1056-62-521 **Mehdi Razzaghi***, Department of Mathematics, Bloomsburg University, Bloomsburg, PA 17815. *The Use of Skew-Normal Distribution for Dose-Response Modeling in Toxicological Experiments.*

In recent years the family of skew-normal distributions has attracted the attention of many statisticians. Several publications have considred various statistical properties of this family. Here, we discuss the application of skew-normal distributions in dose-response modeling. Specifically, we show how this family of distribution provides useful and flexible models. Attention will be focused on developmental neurotoxicity bioassay experiments with animals. We assume that responses conditional on the litter means have a skew-normal distribution. Using a normal distribution to describe the variation among the litter means, the unconditional distribution of mean responses will be derived and its properties will be discussed. Application of the model will illustrated using some experimental data. (Received September 11, 2009)

1056-62-711 **Cuilan Gao*** (cgao@olemiss.edu), 305 Hume Hall University of Mississippi, Oxford, MS 38655, and **Xin Dang**, **Yixin Chen** and **Dawn Wilkins**. *Graph ranking on gene network.*

Microarray technology has made it possible to simultaneously monitor the expression levels of thousands of genes in a single experiment. However, the large number of genes greatly increases the challenges of analyzing, comprehending and interpreting the resulting mass of data. Selecting a subset of important genes is inevitable to address the challenge. Gene selection has been investigated extensively over the last decade. Most selection procedures, however, are not sufficient for accurate inference of underlying biology, because biological significance does not necessarily have to be statistically significant. Additional biological knowledge needs to be integrated into the gene selection procedure. (Received September 16, 2009)

1056-62-738 **Ke Wu*** (kewu@csufresno.edu), Department of Mathematics, California State University, Fresno, 5245 N. Backer Ave. M/S PB108, Fresno, CA 93740. *Estimation of the Convolution of Distributions Under Different Censoring Models of Survival Data.*

In survival analysis, one is often interested in the evaluation of two or more time-dependent stochastic events and their relationships to one another when data are possibly censored. One problem of interest is to estimate the convolution of distributions. In this talk we will describe some estimators for the convolution of distribution functions when the data are under different censoring models including the general right censoring model, Koziol-Green model, and partial Koziol-Green model. We will present the asymptotic properties of the estimators under these different censoring models. (Received September 16, 2009)

1056-62-814 **Loree Kim Killebrew*** (lkkilleb@bsc.edu), Box 540374, 900 Arkadelphia Road, Birmingham, AL 35254, and **Xinyan Yan** (xyan@bsc.edu), Box 540756, 900 Arkadelphia Road, Birmingham, AL 35254. *Rubric-scored Assessments: A Study of Inter-rater Reliability.* Preliminary report.

This study is primarily focused on inter-rater reliability. The subjects of the study are three university faculty members, two undergraduate students, and 44 participants in a mathematics content course for teachers entitled Numerical Reasoning. This course is offered by the Greater Birmingham Mathematics Partnership (GBMP), an NSF-funded Math Science Partnership (award #0632522). A series of rubric training sessions was given by the three faculty members who were familiar with the rubric and the course itself. Using 44 matched pre- and post-test completed by the teachers in the 2008 GBMP course, the undergraduate student-raters independently scored the tests on five different dimensions: Accuracy, Conceptual Understanding, Processes and Strategies, Verification, and Communication. Descriptive statistics were computed for the responses of the three questions on the pre-tests and post-tests. Kappa scores were used to determine inter-rater reliability. A minimum Kappa score of 0.400 was hypothesized as indicative of an acceptable level of inter-rater reliability. This paper reports efforts to achieve such a level of inter-rater reliability and the methods of training. The shortcomings of the training and suggestions for future study will be discussed. (Received September 17, 2009)

1056-62-931 **Eun-Joo Lee*** (elee@millikin.edu), 1184 W.Main st., Decatur, IL 62522, and **Frits Ruymgaart**. *Improving an existing estimator of the unknown input function.*

We consider the usual estimator of a linear functional of the unknown input function in indirect nonparametric regression models. The unknown regression function which is the parameter of interest, is infinite dimensional. Since the function in a separable Hilbert space has a Fourier expansion in an orthonormal basis, the Fourier coefficients will be estimated. It is surprising to see that the traditional estimator of the Fourier coefficients is not asymptotically efficient according to Hajek-LeCam convolution theorem. Since this estimator, however, is $\sqrt{(n)}$ - consistent, it can be improved in an asymptotic sense. The possible improvement of this estimator will be discussed. We will also compare the improved estimator with the traditional estimator through simulation studies. (Received September 18, 2009)

1056-62-1026 **Kobi A. Abayomi*** (kobi@gatech.edu), 765 Ferst Dr., 444 Groseclose Bldg, Georgia Tech, Atlanta, GA 30332, and **Lee Hawkins** and **Kenneth Land**. *Parametric Copula Models for Markovian Processes, for African-American Male Career Heuristics.*

We exploit a Copula - or jointly parameterized, marginally fixed distributional representations - version of a Markovian process on data comparing U.S. African American Male income attainment. We find, under particular dependence regimes, support for heuristics which prefer non-traditional career paths. (Received September 20, 2009)

1056-62-1158 **Galin Jones*** (galin@stat.umn.edu), 224 Church St S.E., Minneapolis, MN 55445. *Evaluation of Formal posterior distributions via Markov chain arguments.*

We consider evaluation of proper posterior distributions obtained from improper prior distributions. Our context is estimating a bounded function $\phi$ of a parameter when the loss is quadratic. If the posterior mean of $\phi$ is admissible for all bounded $\phi$, the posterior is strongly admissible. We give sufficient conditions for strong admissibility. These conditions involve the recurrence of a Markov chain associated with the estimation problem. We develop general sufficient conditions for recurrence of general state space Markov chains that are also of independent interest. Our main example concerns the $p$-dimensional multivariate normal distribution with mean vector $\theta$ when the prior distribution has the form $g(\|\theta\|^2)d\theta$ on the parameter space $\mathbb{R}^p$. Conditions on $g$ for strong admissibility of the posterior are provided. (Received September 21, 2009)

1056-62-1209 **Naoki Saito*** (saito@math.ucdavis.edu), Department of Mathematics, University of California, Davis, One Shields Avenue, Davis, CA 95616, and **Linh Lieu**. *Hyperspectral Image Classification by Matching Node Connectivities.*

We present a simple and efficient scheme for pattern recognition and signal classification within the Diffusion Framework. Our Node Connectivity Matching (NCM) method is derived from the concept of diffusion distance originally proposed by Coifman and Lafon. However, instead of embedding data into a low dimensional diffusion space, which requires computing the eigenvalues and eigenvectors of the normalized diffusion matrix on the graph constructed from the data, we view each row of the normalized diffusion matrix as a training histogram (or probability distribution) of node connectivities. To classify an unlabeled data point, we compute the "distances" between its node connectivity histogram to all the training histograms using various measures such as the $L^2$ norm, the Hellinger distance, the Jeffreys divergence, and/or Earth Mover's Distance. In this talk we will also

show our results on the classification of hyperspectral images of natural scenes and demonstrate that our NCM method is more accurate than using the conventional diffusion distances. (Received September 21, 2009)

1056-62-1351 **Broderick Oluyede*** (boluyede@georgiasouthern.edu), Department of Mathematical Sciences, Georgia Southern University, Statesboro, GA 30460. *Characterization and Dispersive Ordering of the Cauchy, Gauss and Logistic Laws.*

In this talk, I present some results on the characterization and dispersive ordering of the general Cauchy, logistic and normal laws. The characterization of the Cauchy law is accomplished via a convex function of a symmetric random variable, as well a differential equation involving the characteristic function. Results on the characterization of the logistic distribution shed further light into its application in a wide variety of areas including the analysis of quantal response and bioassay data, as well economic and demographic data. These results lead to necessary and sufficient conditions for the stochastic and dispersive ordering of the corresponding absolute random variables. (Received September 21, 2009)

1056-62-1374 **Talithia D Williams*** (twilliams@hmc.edu), 301 Platt Blvd., Claremont, CA 91711. *Calculating target Cataract Surgical Rates for Africa.*

Cataract remains the leading cause of blindness in Africa and planning for its treatment is a priority of the World Health Organization's VISION 2020 initiative. The cataract surgical rate (CSR), the number of operations done per million population, is a convenient indicator for planning and monitoring. However, estimating what the CSR needs to be to eliminate blindness requires one to take into account a number of factors and assumptions. The recently developed Rapid Assessment of Avoidable Blindness (RAAB) survey uses a population-proportional-to-size sampling technique to select a representative group of people over 50 years old to receive a standard eye exam. We use current data from RAAB surveys in Africa to model the epidemiology of visually significant cataract and to estimate the incidence of cataract causing loss of visual acuity at different age levels. In this talk, I describe our method of estimating incidence from prevalence and how this information can be used to help set target CSR's for various geographical locations in Africa, taking into account important differences among populations. (Received September 21, 2009)

1056-62-1387 **Emily K Bice*** (ebice@csu.fullerton.edu), **Venkata V Chebrolu**, **Huanzhou Yu**, **Jean H Brittain**, **Scott B Reeder** and **Angel R Pineda**. *Cramer-Rao Bound for Estimating Non-linear Parameters in a Model for Chemical Species Separation using Magnetic Resonance Imaging.*

Magnetic resonance images typically contain signals from multiple chemical species such as water and fat. The diagnostic information in the image can be improved by separating the components of the signal coming from individual chemical species. The model that describes the signal generation includes non-linear parameters which arise from imperfections in the magnetic field and signal decay. The Cramer-Rao Bound is the minimum variance of an unbiased estimator of a parameter. In this work, we use the Cramer-Rao Bound to optimize the data acquisition for the non-linear inverse problem of estimating the magnetic field inhomogeneities and signal decay. (Received September 21, 2009)

1056-62-1426 **Akram M Almohalwas*** (almoh1am@cmich.edu), 210 S. Bradley St. Apt. 206, Mt. Pleasant, MI 48858. *Compound Covariate Predictor (CCP) Classification Technique Applied on More Than Two Groups Gene Expression data.* Preliminary report.

Many of the gene expression data have more than two groups with a large Variable to Samples ratio. This requires some data mining techniques to reduce the dimensionality of these data sets. Parametric as well as nonparametric statistics are used as weights to help in classifying classes of genetic diseases that has more than two groups using One Vs. All, and All Pairwise Combination to be able to correctly classify samples to the correct Cancer subclass. One can classify genetic cancer disease data with very high accuracy and very few number of genes. (Received September 21, 2009)

1056-62-1452 **Jeff Hamrick*** (hamrickj@rhodes.edu), 2000 N. Parkway, Memphis, TN 38104, and **Yifei Huang**, **Kostas Kardaras** and **Murad S Taqqu**. *Computing a Penalized Maximum Quasi-Likelihood Estimator of the Diffusion Coefficient.*

We consider a class of diffusion models with deterministic coefficient functions that are allowed to depend on the level of the diffusion. We develop a nonparametric estimation procedure for the diffusion coefficient based on a penalized maximum quasi-likelihood method. After discussing the challenges associated with computation of this estimator and implementing the technique on several simulated and real-world sets of data, we discuss the rate of convergence of this estimator. (Received September 21, 2009)

1056-62-1564 **Ming Ye*** (mye@fsu.edu), 400 Dirac Science Library, Department of Scientific Computing, Florida State University, Tallahassee, FL 32306. *Groundwater Reactive Transport Modeling under Uncertainty.*

Groundwater environmental systems are open and complex, in which intricate biological, physical, and chemical processes occur and interact at multiple scales. Groundwater reactive transport modeling is entailed for understanding and predicting the system responses to natural forces (e.g., climatic) and human activities (e.g., contaminant remediation and CO2 sequestration). The modeling results are critical for effectively managing groundwater contamination and for providing a scientific basis for decision making. However, uncertainty is one of the greatest obstacles to groundwater reactive transport modeling. It is well known that uncertainties are large in characterization and description of the groundwater system. This study is focused on quantifying uncertainty in describing uranium sorption. Based on the surface complexation theory, a total of seven geochemical models are postulated with different degrees of complexity. These models are evaluated using the breakthrough data of three column experiments, and their predictive performance is investigated using the breakthrough data of four column experiments. The study manifests importance of addressing model structure uncertainty in groundwater reactive transport modeling. (Received September 22, 2009)

1056-62-1599 **Hiroyuki Takeda** (htakeda@soe.ucsc.edu), 1156 High Street, SOE2, Santa Cruz, CA 95064, **Hae Jong Seo** (rokaf@soe.ucsc.edu), 1156 High Street, SOE2, Santa Cruz, CA 95064, and **Peyman Milanfar*** (milanfar@ee.ucsc.edu), 1156 High Street, SOE2, Santa Cruz, CA 95064. *Locally Adaptive Kernel Regression: A Non-parametric Framework for Multidimensional Signal Processing and Analysis.*

I will present a non-parametric framework based on the notion of Kernel Regression which we generalize to adapt to local characteristics of the given data, resulting in descriptors which take into account both the spatial density of the data samples ("the geometry"), and the actual values of those samples ("the radiometry"). These descriptors are exceedingly robust in capturing the underlying structure of multidimensional signals even in the presence of significant noise, missing data, and other disturbances. As the framework does not rely upon strong assumptions about noise or signal models, it is applicable to a wide variety of problems. Of particular interest in two and three dimensions are state of the art denoising and upscaling of images and video. Of recent relevance to computer vision, I will describe the novel application of the framework to object and action detection/recognition in images, and in video, respectively, from a single example. (Received September 22, 2009)

1056-62-1848 **Mavis Pararai*** (pararaim@iup.edu), Mathematics Department, Stright Hall, Room 233, 210 South Tenth Street, Indiana, PA 15705. *Underrecording in Domestic Violence Data Using Count Data Regression Models.*

Underrecording of events is a common problem in count data. This might be due to the nature of the event under consideration. People tend to underrecord the number of abuses they have suffered at the hands of a spouse, number of times they have been convicted of some criminal activity and many other events they think are embarrasing. Domestic violence data is often underrecorded. We compare results obtained from Poisson, Negative Binomial and Generalized Poisson regression models for underrecorded counts using Domestic Violence Data. Estimation of model parameters is via the maximum likelihood methods. Ignoring underrecording of events results in biased estimates. (Received September 22, 2009)

1056-62-1851 **Jean Marie Linhart*** (jmlinhart@gmail.com), Department of Mathematics, Texas A&M University, Mail Stop 3368, College Station, TX 77843-3368, and **Wolfgang Bangerth** (bangerth@math.tamu.edu), Department of Mathematics, Texas A&M University, Mail Stop 3368, College Station, TX 77843-3368. *Statistical Sampling in High Dimensional Inverse Problems.*

Inverse problems arise in fields where abstract model parameters must be inferred from real-world data. In optical tomography we attempt to detect tumors at unknown locations in the human breast based on light measurements on the boundary modeled by a system of PDEs. Determining the material properties of the breast to a resolution of about 1 $mm^3$ requires $\sim$200 grid points using adaptive finite element methods. At each grid point we find optical scattering and absorption coefficients; they are indicators of the presence of tumors. We wish to determine the form of the $\sim$200-dimensional posterior distribution; this requires statistical sampling. The objective of our work is to find good sampling methods for use with such high-dimensional problems. We explore the use of the delayed-rejection adaptive-Metropolis (DRAM) method for high-dimensional sampling. This method modifies the Metropolis Hastings algorithm to reduce the rejection rate; it is a non-Markovian sampler that has correct ergodic properties. We will show that this method can be applied to identify the correct posterior distribution for a complex model based on the Poisson equation that can be thought of as a simplified description of optical tomography. (Received September 22, 2009)

1056-62-2020 **Raymond E. Molzon*** (remolzon@mtu.edu), 1400 Townsend Dr., Mathematical Sciences, Houghton, MI 49931. *The minimum measure of concordance in a multivariate version of Spearman's rank correlation.* Preliminary report.

Spearman's rank correlation is an asymptotically unbiased estimator of the grade correlation $\rho_S$ between two random variables $X$ and $Y$, and $\rho_S$ is an instance of a bivariate measure of concordance. It is known that $\rho_S$ attains its minimum value of $-1$ when $Y$ is almost surely a strictly decreasing function of $X$. In a multivariate setting, where $\rho_S$ is a measure of concordance between $k$ random variables $X_1, \ldots, X_k$, we use geometric reasoning about the grade correlation to show that the minimal value of $\rho_S$ is $-\frac{1}{k-1}$ and consider an example distribution where this minimal value is attained. (Received September 22, 2009)

1056-62-2095 **Eric R Ruggieri*** (eric_ruggieri@brown.edu), 16 Fuller Rd. Apt 2, Foxboro, MA 02035, and **C. Lawrence**. *The Mid-Pleistocene Transition: From Forcing to Pacing of Glaciers.* Preliminary report.

Milankovitch Theory proposes that glaciers are controlled by the amount of solar insolation received at 65N latitude. However, the Mid-Pleistocene Transition and subsequent emergence of 100 kyr glaciations have posed a challenge to this Theory. Allowing the parameters of a model to change through time may be one way to solve this dilemma. The change point algorithm optimizes over not only the parameters of the model but also the timing of the regimes changes. Our analysis has found that the Mid-Pleistocene Transition was a time when the glacial system changed from a forced system to a paced system. We have also found that the best fitting solar insolation curve is not summer 65N as proposed by Milankovitch Theory, but summer 65S, or winter 65N. (Received September 23, 2009)

1056-62-2147 **Li Zhu*** (lzhu@math.wsu.edu), 1630 NE VALLEY RD X106, PULLMAN, WA 99163, and **Haijun Li**. *Coherent risk measure for multivariate Pareto distributed losses.* Preliminary report.

Extremal dependence has been observed in diverse fields, such as data network, financial risk management, environmental impact assessment, etc. The extremal risk fueled by extremal dependence and its contagious adverse effects have been best illustrated from the current financial crisis. This research focuses on extremal risk assessment for financial portfolio that has multivariate Pareto distributions. A multivariate coherent risk measure corresponds to a set of deterministic portfolio that represents a vector of extra capitals needed so that the resulting positions are acceptable to regulators/supervisors. In this research, we study tail conditional expectation (TCE), a multivariate coherent risk measure, for dependent Pareto distributed financial losses. TCE used in continuous risk analysis describes the expected amount of risk that could be experienced given that a potential risk exceeds a threshold value, and is preferable than the value-at-risk (VaR), a risk measure that is widely used but fails to satisfy the coherency principle. We derive explicit tractable lower and upper bounds for TCE, which can be applied to diverse fields for accurate estimates of extremal risks. (Received September 23, 2009)

# *65 ► Numerical analysis*

1056-65-30 **Leon Kaganovskiy*** (lkaganovskiy@ncf.edu), 3525 Cheshire Sq, apt B, Sarasota, FL 34237, and **Robert Krasny** (lkaganovskiy@ncf.edu) and **Feng Hualong** (lkaganovskiy@ncf.edu). *Numerical techniques for 3-D Vortex Rings Motion and Collision.*

We consider a panel method for computing vortex sheet motion in 3D flow. The sheet is represented as a set of quad-tree panel structure. The panels have active particles that carry circulation and passive particles used for adaptive panel subdivision. The new feature of this scheme is that the explicit derivatives of the flow map are not required. The Biot-Savart kernel is regularized and the velocity is evaluated by a multipole treecode. The method is applied to azimuthally unstable single vortex ring as well as vortex rings collision. Vorticity isosurfaces are investigated and compared to experimental results. (Received June 22, 2009)

1056-65-123 **Yun Guan*** (guan@math.uic.edu), Dept. of Math. Stat. and CS, University of Illinois at Chicago, 322 Science and Engineering Offices (M/C 249), Chicago, IL 60607, and **Jan Verschelde** (jan@math.uic.edu), Dept. of Math. Stat. and CS, University of Illinois at Chicago, 322 Science and Engineering Offices (M/C 249), Chicago, IL 60607. *Local Numerical Representation of Algebraic Sets.*

Numerical data structures for positive dimensional solution sets of polynomial system are sets of generic points cut out by random planes. We may represent the linear spaces defined by those planes either by explicit linear equations or in parametric form. These descriptions are respectively called extrinsic and intrinsic representations. Previous work by Andrew Sommese, Jan Verschelde, and Charles Wampler showed how the intrinsic formulation of diagonal homotopies reduced the cost of the linear algebra operations during path following. However, we observe that intrinsic representation leads to worse condition numbers. By adapting intrinsic coordinates locally, we show that the conditioning is improved. This is a joint work with Jan Verschelde. (Received July 28, 2009)

1056-65-151 **Yekaterina Epshteyn*** (rina10@andrew.cmu.edu), Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213. *Chemotaxis and Numerical Methods for Chemotaxis Models.*

In this work, first we will discuss several chemotaxis models including the classical Keller-Segel model. Chemotaxis is the phenomenon in which cells, for example bacteria, and other single-cell or multicellular organisms direct their movements according to certain chemicals in their environment. In our work we propose a family of new interior penalty discontinuous Galerkin methods for the Keller-Segel chemotaxis model. The first step in the derivation of the proposed methods is made by introducing the new variable for the gradient of the chemoattractant concentration and by reformulating the original Keller-Segel model in the form of a convection-diffusion-reaction system. We then design interior penalty discontinuous Galerkin methods for the rewritten Keller-Segel system. Our methods employ the central-upwind numerical fluxes, originally developed in the context of finite-volume methods for hyperbolic systems of conservation laws. We prove error estimates for the proposed high-order discontinuous Galerkin methods. Our proof is valid for pre-blow-up times since we assume boundedness of the exact solution. Some numerical experiments to demonstrate the performance of the proposed methods and comparison with other methods will be presented. (Received September 04, 2009)

1056-65-165 **David Alexander Hannasch*** (DavidH@cs.unlv.edu), 3569 East Reno Avenue, Las Vegas, NV 89120, and **Monika Neda** (Monika.Neda@unlv.edu). *Efficient simulation of fluid flow.* Preliminary report.

We are computationally investigating fluid flow models, for physically correct predictions of flow structures. The Navier-Stokes equations, the fundamental equations of fluid flow, are numerically solved via the continuous finite element method alongside models based on the idea of filtering the small scales/structures. Crank-Nicolson and fractional-step schemes are used for the discretization in time, while the Taylor-Hood and Mini elements are used for the discretization in space. The effectiveness of models and of discretizations in time and space are examined by studying the accuracy of flow characteristics, such as drag, lift and pressure drop about a body immersed in a fluid. (Received August 10, 2009)

1056-65-453 **Ben Niu*** (nben@iit.edu), Applied Mathematics Office, Engineering 1 Building, Chicago, IL 60616, **Fred Hickernell** (hickernell@iit.edu), Applied Mathematics Office, Engineering 1 Building, Chicago, IL 60616, and **Thomas Müller-Gronbach** and **Klaus Ritter**. *Evaluating expectations of functionals of Brownian motions: a multilevel idea.*

Pricing a path-dependent financial derivative, such as an Asian option, requires the computation of $E[g(B(\cdot))]$, the expectation of a payoff functional, $g$, of a Brownian motion, $(B(t))_{t=0}^{T}$. The expectation is an infinite-dimensional integration which is approximated by the sample average of a $d-$dimensional approximation to the Brownian motion. In this talk, a multilevel algorithm with low discrepancy designs is used to improve the convergence rate of the worst case error. The paper investigates the worst case error as a function of each level $l$'s sample size, $n_l$, and truncated dimension, $d_l$, for payoff functionals that arise from certain Hilbert spaces with moderate smoothness. If the error in approximating an infinite dimensional expectation by a $d-$dimensional integral is $\mathcal{O}(d^{-q})$, and the error for approximating a $d-$dimensional integral is $\mathcal{O}(n^{-p})$, independent of $d$, then it is shown that the error in computing the infinite dimensional expectation may be as small as $\mathcal{O}(N^{-\min(p,q)})$ for a well-chosen multilevel algorithm, where $N$ is the cost of the algorithm defined as $N = n_1 d_1 + \cdots + n_L d_L$. Numerical experiments in computational finance will be presented. (Received September 08, 2009)

1056-65-454 **Guohui Song*** (gsong3@iit.edu), Department of Applied Mathematics, Illinois Institute of Technology, 10 West 32nd Street, Chicago, IL 60616, and **Yuesheng Xu**, Department of Mathematics, Syracuse University, Syracuse, NY 13244. *Approximation of kernel matrices with multilevel circulant matrices.*

Kernel-based methods have gained popularity in a variety of fields such as approximation, interpolation, meshless methods, neural networks and machine learning. A common problem of these kernel-based methods is to calculate the inverses of the matrices generated by a kernel function and a set of points. However, the computational cost of calculating the inverses of kernel matrices is a major concern. This work focuses on developing fast algorithms for calculating the inverses by approximating the kernel matrices with related multilevel circulant matrices so that the fast Fourier transform can apply to reduce the computational cost of calculating the inverses to $O(n\log(n))$, where n is the size of the matrix. Convergence analysis of the approximation method is established and numerical examples are presented to demonstrate the approximation accuracy and computational efficiency. (Received September 08, 2009)

1056-65-504 **Katharine F. Gurski*** (kgurski@howard.edu), Howard University, Department of Mathematics, Washington, DC 20052, and **Stephen O'Sullivan**, Dublin City University, Ballymun Road, Glasnevin, Dublin, DUBLIN 9, Ireland. *A stability study of a new explicit numerical scheme for a system of differential equations with a large skew-symmetric component.*

Explicit numerical methods for the solution of a system of stiff differential equations suffer from a time step size that approaches zero in order to satisfy stability conditions. Implicit schemes allow a larger time-step, but require more computations. When the differential equations are dominated by a skew-symmetric component, the problem is not stiffness in the sense that the size of the eigenvalues are unequal, rather the that the real eigenvalues are dominated by imaginary eigenvalues. We present and compare analytical results for several explicit methods including the super-time-stepping method of Alexiades, Amiez, and Gremaud which is a explicit Runge-Kutta method and a new method modeled on a predictor-corrector scheme with multiplicative operator splitting. This new explicit method, presented in regular and super-time-stepping form, increases stability without forcing the step size to zero. (Received September 10, 2009)

1056-65-513 **Michel Volker*** (michel@mathematik.uni-siegen.de), Geomathematics Group, Department of Mathematics, University of Siegen, 57068 Siegen, Germany. *Regularization of Inverse Magnetoencephalography by a Spline Method.*

Inverse Magnetoencephalography focusses on the determination of the electric currents inside the brain out of data of the magnetic field at the skin. It is well-known that this inverse problem is not uniquely solvable. Therefore, certain constraints have to be imposed on the geometry and the currents for a unique solution. Moreover, data are only given at approximately a hemisphere such that global spherical methods (such as expansions in spherical harmonics) are not appropriate. This talk discusses a particular simplified layer model of the brain. Based on this modelling, a reproducing kernel based spline method (which is related to established techniques in signal processing) is used to regularize the inverse problem. One particular feature of the method is that an almost real-time calculation of the solution is possible. The numerical results show that close approximations to the exact solution can be obtained, even for noisy data.

References

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(Received September 11, 2009)

1056-65-518 **Michael Joseph Neilan*** (neilan@math.lsu.edu), Center for Computation and Technology, Louisiana State University, Baton Rouge, LA 70803, and **Susanne C. Brenner**, **Thirupathi Gudi** and **Li-yeng Sung**. *$C^0$ interior penalty methods for fully nonlinear Monge-Ampère type equations.*

In this talk, we formulate and study $C^0$ interior penalty Galerkin methods for the fully nonlinear Monge-Ampère equation $\det(D^2u) = f\ (> 0)$ and Gauss curvature equation $\det(D^2u) = (1 + |\nabla u|^2)^2$ with Dirichlet boundary conditions in two dimensions. The approach we take is based on the vanishing moment method which is a constructive way to approximate fully nonlinear second order PDEs. In the case of the Monge-Ampère equation, the vanishing moment approximation is the solution to the fourth order semi-linear equation $-\epsilon\Delta^2u^\epsilon + \det(D^2u^\epsilon) = f$ with appropriate boundary conditions. We briefly describe a proof of existence of the vanishing moment approximation $u^\epsilon$ as well derive convergence rates of the error $u - u^\epsilon$ provided that $u$

is sufficiently smooth. We then construct $C^0$ symmetric interior penalty methods for the regularized problem. (Received September 11, 2009)

1056-65-545 **Qin Sheng*** (`Qin_Sheng@baylor.edu`), Department of Mathematics, Baylor University, One Bear Place, Waco, TX 76798-7328, and **Anzhong Wang** (`Anzhong_Wang@baylor.edu`), Department of Physics, Baylor University, One Bear Place, Waco, TX 76798-7316. *An exploration of the numerical approximations of dynamic derivatives for adaptive computations.* Preliminary report.

Various kinds of dynamic equations have been used recently in modeling important natural phenomena, including the population or epidemic growth with unpredictable jump sizes, motion control of impulsive robot movements, and prediction of irregular option pricing markets. Since dynamic derivatives are basic building blocks of the dynamic equations, to solve the equations numerically, we will have to approximate the dynamic derivatives for yielding computable discrete systems for computers. This discussion will show one of our recent investigations. A class of feasible approximation methods for first and second order non-crossed dynamic derivatives will be proposed. Applicable local error analysis will be given. Some numerical experiments will be carried out to illustrate our results. (Received September 11, 2009)

1056-65-554 **nan jiang*** (`njiang@usd.edu`), Math Dept of University of South Dakota, 414 E. Clark St, Vermillion, SD 57069. *On the Convergence of Fully-discrete High-Resolution Schemes with van Leer's flux limiter for Conservation laws.* Preliminary report.

A class of fully-discrete high-resolution schemes using flux limiters was constructed by P. K. Sweby [*SIAM J. Numer. Anal.* 21 (1984), 995-1011], which amounted to add a limited anti-diffusive flux to a first order scheme. This technique was very successful in obtaining high-resolution, second order, oscillation free, explicit difference schemes. However, the entropy convergence of such schemes has been open. For the scalar convex conservation laws, we use one of Yang's convergence criteria [*SIAM. J. Numer. Anal.* 36 (1999) No. 1, 1-31] to show the entropy convergence of the schemes with van Leer's flux limiter when the building block of the schemes is the Godunov or the Engquish-Osher. The entropy convergence of the corresponding problems in semi-discrete case, for convex conservation laws with or without a source term, has been settled by Jiang and Yang [*Methods and Applications of Analysis* Vol. 12 (2005), No. 1 pp. 089-102]. (Received September 12, 2009)

1056-65-616 **Eun-Hee Park*** (`epark2@math.lsu.edu`), Center for Computation & Technology, Louisiana State University, 332 Johnston Hall, Baton Rouge, LA 70803, and **Chang-Ock Lee**. *A Dual Iterative Substructuring Method with a Penalty Term in Three Dimensions.*

In our previous work [Numer. Math. 112 (2009), 89–113] for two dimensional problems, a dual iterative substructuring method was proposed, which is a variant of the FETI-DP method. Unlike the FETI-DP method, the proposed method imposes the continuity by not only the pointwise matching condition on the interface but also using a penalty term which measures the jump across the interface.

In this talk, we introduce an extension of a dual substructuring method with a penalty term to three dimensional problems. By focusing on the geometric complexity of an interface in 3D caused by the coupling among adjacent subdomains, a penalty term with a penalization parameter $\eta$ is constructed, which makes the associated 3D algorithm more efficient in practical sense. In spite of the absence of any preconditioners, it is shown that for a large $\eta$, the condition number of the resultant dual problem is bounded by a constant independent of both the subdomain size $H$ and the mesh size $h$. From the implementational viewpoint of the proposed method, special attention is paid to establish an optimal preconditioner with respect to a penalization parameter $\eta$ in order to prevent a large penalization parameter from making subdomain problems ill-conditioned. (Received September 14, 2009)

1056-65-691 **Ishani Roy*** (`iroy@dam.brown.edu`), Brown University, Box F, Division of Applied Mathematics, Providence, RI 02912, and **Wen Xu**, **Jing-Mei Qiu**, **Chi-Wang Shu** and **Li-Zhi Fang**. *A higher order WENO algorithm to solve radiative transfer of photons in the 'early universe'.*

This talk will present the analysis and computation of a certain high order numerical scheme used in computational Cosmology. The algorithm is based on the weighted essentially non-oscillatory (WENO) scheme for Boltzmann-like integral differential equations. The numerical method will be illustrated with a particular application in Astrophysics that defines the transfer of photons by Hydrogen gas during the formation of the first stars in 'Early Universe'. (Received September 15, 2009)

1056-65-796 **James B Collins*** (jbcolli2@ncsu.edu), Raleigh, NC 27609. *The Domain Decomposition Method Applied to Hyperbolic Network Problems.*

Network problems are PDEs defined on the edges of a network. These include problems in traffic flow, gas pipelines, and the circulatory system. We consider hyperbolic problems defined on a network and apply the domain decomposition method. The goal of this talk is to determine under what conditions the domain decomposition method speeds up computation. These conditions depend partially on the final time $T$ to which the problem is solved. Theoretical results are obtained for the linear acoustics equations on certain networks. Numerical results are shown for the linear acoustics and the nonlinear traffic flow equations on more general networks. (Received September 17, 2009)

1056-65-845 **Fred J. Hickernell*** (hickernell@iit.edu), Room E1-208, Applied Mathematics, Illinois Institute of Technology, 10 W. 32nd St., Chicago, IL 60616. *Kernel Based Function Approximation in High Dimensions.*

Optimal methods for approximating functions in a Hilbert space based on noisy data employ the reproducing kernel of that Hilbert space. Such methods include smoothing splines, radial basis function methods, meshfree methods, etc. This kernel can also be used to provide a tight error bound. This talk highlights new error bounds whose convergence rates are independent of the dimension. This depends on a good choice of function space and a good design. (Received September 17, 2009)

1056-65-925 **Aycil Cesmelioglu*** (aycil.cesmelioglu@rice.edu), Rice University, Computational and Applied Mathematics Dept., 6100 Main St. MS-134, Houston, TX 77054. *Analysis and simulation of a multiphysics and a multiphase problem.*

First, we analyze and simulate the Navier-Stokes and Darcy flow problem coupled to a transport equation by the velocity field, modeling the transport of the contaminants through lakes and rivers. Using a numerical scheme based on Backward Euler and a discontinuous Galerkin (DG) method over the whole domain, we obtain an error that is optimal in space and first order in time. Second, we develop high order DG methods for the flow in porous media of three immiscible fluids such as water, oil and gas. The proposed discretization, based on the DG methods in space and the backward Euler method in time is decoupled by solving sequentially and time-lagging the nonlinear coefficients. (Received September 18, 2009)

1056-65-951 **Marlene Willie-Aymone Ouayoro*** (mouayoro@gmu.edu), 4615 Cambryar Street, Fairfax, VA 22030. *Retrieving Economic Parameters in Asset-Flow Equations.*

Over its time-series, a financial instrument's price can reflect asset overpricing or under-valuation. This research attempts to replicate the observed price points through the Caginalp-Balenovich differential equation and measure their accuracy with the actual points. Then we fit our curve to the observed curve using the Gauss-Newton (iterative) Method to estimate the initial parameters of the differential equation. (Received September 18, 2009)

1056-65-986 **Martin Brown*** (martinebrown@berkeley.edu), **Mary Broadbent** and **Kevin Penner**. *A COMPARISON OF ALGORITHMS FOR SUBSET SELECTION.* Preliminary report.

Subset selection is a method for selecting a subset of columns from a real matrix, so that the subset represents the entire matrix well and is far from being rank deficient.

We investigate a two-stage algorithm for subset selection that utilizes a randomized stage to improve computing speed for large problems and achieves asymptotic bounds that are superior to the best existing deterministic algorithm. After experimentation on test matrices of dimension up to 500, we find that that the randomized algorithm, when run 40 time, differs from the deterministic algorithm by less than an order of magnitude with respect to our two criteria of matrix approximation and linear independence.

We also propose a new two stage deterministic algorithm that performs as well as the other algorithms. We conclude that, due to the difficulties of implementing the randomized algorithm efficiently, deterministic methods should remain the algorithms of choice for matrices of moderate size. (Received September 19, 2009)

1056-65-1021 **Malena Espanol*** (mespanol@caltech.edu), Graduate Aeronautical Laboratories, California Institute of Technology, 1200 E. California Blvd. MC: 205-45, Pasadena, CA 91125, and **Misha Kilmer**. *A Multilevel, Modified Regularized Total Least Norm Approach to Signal Deblurring.*

In this talk, we present a multilevel method for discrete ill-posed problems formulated as total least norm problems. We will focus on the signal deblurring problem where both the blurring operator and the blurred signal contain noise. Regularized total least norm (R-TLN) approaches which have been developed to solve this problem require the minimization of a functional with respect to the unknown perturbation in the blurring operator and the desired image. Much of the work to date in solving R-TLN has required the perturbation operator to have special structure (e.g. sparsity structure or Toeplitz type structure) in order to make the minimization problem more computationally tractable. Our goal is to gain additional efficiency by means of a multilevel approach. Therefore, we present a multilevel method that uses the Haar wavelets as restriction and prolongation operators. We show that the choice of the Haar wavelet operator has the advantage of preserving matrix structure, such as Toeplitz, among grids, and we discuss how this can be incorporated into intermediate R-TLN problems on each level. Finally, we present results that indicate the promise of this approach on deblurring signals with edges. (Received September 20, 2009)

1056-65-1058 **Yuan He***, 200. S. W. Mudd Building, MC 4701, 500 W. 120th Street, New York, NY 10027, and **David E Keyes**. *Reconstructing physical parameters in systems of reaction-diffusion equations in electrocardiology.*

We consider distributed parameter identification problems for two electrocardiology models: the FitzHugh-Nagumo model and the bidomain model. These models describe the evolution of electrical potentials in heart tissues. The objective of these inverse problems is to reconstruct coefficients in these electrocardiology models from electrical potential measurements.

We constructed numerical reconstruction algorithms of Newton-Krylov-Schur-Schwarz type to solve the inverse problems. These iterative algorithms combine Newton's method for numerical optimization with Krylov subspace solvers for the resulting reduced Karush-Kuhn-Tucker (KKT) system. Schwarz-type methods are used to solve the partial differential equations that are involved in the inversion procedure. We implemented the algorithms on parallel processors so that we can solve the reconstruction problem in large-scale parallel environments.

We will present numerical examples for reconstructions with both time-dependent measurements and time-independent measurements. We show by numerical simulations that parameter reconstruction can be performed from measurements at various locations of the domain, including interior, boundary, and the combination. (Received September 20, 2009)

1056-65-1125 **Mazen George Zarrouk*** (mzarrouk@uwm.edu), University of Wisconsin - Milwaukee, PO Box 413, Milwaukee, WI 53201, and **Dexuan Xie** (dxie@uwm.edu). *Truncated Incomplete Hessian Newton Minimization with Application to Biomolecular Potential Energy Function.*

In a recently published paper, we proposed and analyzed a new type of a modified Newton linesearch method, called the truncated incomplete Hessian Newton (T-IHN), for minimizing a twice continuously differentiable real-valued function whose Hessian matrix is dense but can be well approximated by a sparse incomplete Hessian matrix. We proved that T-IHN is globally convergent even with an indefinite incomplete Hessian matrix or an indefinite preconditioner, which may happen in practice. We also proved that when the T-IHN iterates are close enough to a minimum point, T-IHN admits a steplength of one that satisfies the Wolfe's conditions and that T-IHN has a Q-linear rate of convergence. As an important application, we constructed a particular T-IHN algorithm for minimizing a biomolecular potential energy function, and numerically tested it for a protein model problem based on a widely used molecular simulation package, CHARMM. Numerical results confirm the theoretical results, and demonstrate that T-IHN can have a better performance than most CHARMM minimizers. In this talk, we will describe the T-IHN method, show its major convergence results, describe the construction of the incomplete Hessian matrix, and present some of the promising numerical results of T-IHN. (Received September 21, 2009)

1056-65-1132 **Michel Volker*** (michel@mathematik.uni-siegen.de), Geomathematics Group, Department of Mathematics, University of Siegen, 57068 Siegen, Germany. *Spherical Harmonics, Splines and Wavelets — What Comes Next?*

For a long time, spherical harmonics have been the only remarkable mathematical tool for the analysis of spherical functions. Although there is still a series of applications, their use becomes less and less important in numerical implementations. Several more sophisticated mathematical tools for spherical functions (such as spherical splines and wavelets) have superseded orthogonal polynomials as the first choice method during the last decades. This talk discusses what could be the next step in developing new methods for the analysis of spherical functions. One answer could be "let's become non-linear". This means that non-linear methods are possible improvements. On the Euclidean domain, dictionary-based methods recently became popular. The principle ideas can be transferred to the sphere, as it is shown in the talk. Moreover, "non-linear" refers not only to the methods but also to the problems since there is also a need for good approximation methods to solve non-linear problems in geomathematics. One example occurs in the joint inversion of seismic and gravity data for the modelling of the Earth's interior. (Received September 21, 2009)

1056-65-1148 **Hans Z Munthe-Kaas*** (hans@math.uib.no), Johannes Bruns gt. 12, N-5008 Bergen, Norway. *On applications of non-commutative Fourier analysis in computational science.*

Classical Fourier analysis deals with analysis and computational techniques for Linear Translation Invariant operators, i.e. linear operators commuting with shifts on Abelian groups, such as $R^n$, $R^n/2\pi Z$, $Z$ and $Z/NZ$ and products of these. More generally, Fourier analysis on groups deals with linear operators commuting with shifts on non-commutative groups. Here (matrix valued) group representations replaces exponentials in the classical Fourier analysis.

In this talk we will discuss various problems in computational mathematics where ideas of non-commutative harmonic analysis plays a central role. In particular we will discuss symmetry based techniques for computational linear algebra (matrix exponentials, eigenvalue computations and linear solvers) as well as recent developments of multivariate Chebyshev polynomials in approximation theory. These polynomials are closely associated with affine Weyl groups and share most of the beautiful properties of the classical univariate Chebyshev polynomials.

The talk is aimed at a general mathematical audience. We will present central ideas, applications and open problems. (Received September 21, 2009)

1056-65-1160 **ronald r coifman*** (coifman@math.yale.edu), Dept of Mathematics, Yale Universit y, 10 Hillhouse ave, New Haven, CT 06520, and **gavish matan**. *Harmonic Analysis and Geometries of Digital Data Bases . Ronald Coifman , Matan Gavish Yale University.*

Given a matrix (of Data) we describe methodologies to build two multiscale (inference) Geometries/Harmonic Analysis one on the rows , the other on the columns . The geometries are designed to simplify the representation of the data base . We will provide a number of examples including; matrices of operators , psychological questionnaires, vector valued images, scientific articles, etc. In all these cases tensor Haar orthogonal bases play a crucial role in organizing the data base viewed as a function of two variables (row, column) in the case of potential operators we relate to Calderon Zugmund decompositions , while for other data this is a "data agnostic analytic learning tool" (Received September 21, 2009)

1056-65-1182 **P. A. Lott*** (Aaron.lott@nist.gov), National Institute of Standards & Technology, 100 Bureau Dr. Stop 8910, Gaithersburg, MD 20899-8910, and **H. C. Elman**, MD. *Fast Solvers for Models of Steady Fluid Flow.*

Numerical simulation provides insight into the effect physical parameters have on fluid flows under conditions that make physical experiments and theory intractable. However, these simulations are computationally demanding and in order to extend their applicability, highly scalable and efficient numerical methods are being developed. We discuss a novel block preconditioner based on domain decomposition and fast diagonalization that can be used to accelerate iterative solution methods. We then demonstrate how this technique provides an efficient means of simulating steady fluid flows. (Received September 21, 2009)

1056-65-1185 **Jean-Paul Berrut*** (jean-paul.berrut@unifr.ch), Department of Mathematics, University of Fribourg, Chemin du Musee 23, CH-1700 Fribourg, Switzerland. *Fighting Gibbs' phenomenon through quotienting.* Preliminary report.

Gibbs' phenomenon, the overshooting at jumps, is a very annoying drawback of infinitely smooth approximants. Many methods for its alleviation have been suggested, in the past as well as and in recent years, see, e.g., the book by Jerri and the articles by Gottlieb, Gelb, Brezinski, Beckermann and their coauthors. Many of these methods do not act in physical space, but rather in a transformed space.

A very simple method working in physical space seems to have been overlooked so far. It is based on the following observation: for a given approximation operator, the quotient of the approximant and the approximated function $f$ is very similar for various $f$. In this talk I shall present some conjectures precizing this observation and demonstrate how it may be used to alleviate, and in many cases even eliminate, the phenomenon. (Received September 21, 2009)

1056-65-1193 **Andrew T. Barker*** (andrewb@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, and **Susanne C. Brenner**. *Parallel computation with the weakly over-penalized symmetric interior penalty method.*

Weakly over-penalized symmetric interior penalty methods have many desirable properties for parallel computing. These include small communication requirements at subdomain boundaries and intrinsic parallelism in the resulting matrix systems if the unknowns are ordered properly. The WOPSIP method, which is a non-conforming finite element method, shows promise for large-scale parallel computing because of this and because it is well-suited to adaptive refinement of meshes. We explore the possibilities of WOPSIP methods for the solution of PDEs on parallel computers, and compare these methods to other approaches including conforming finite elements. We also examine the effectiveness of several domain decomposition strategies for the WOPSIP method and present numerical results for model problems. (Received September 21, 2009)

1056-65-1216 **Ethan K Murphy*** (ethan.kane.murphy@gmail.com), Rensselaer Polytechnic Institute, Biomedical Engineering Dept - 7049 JEC, 110 8th St., Troy, NY 12180, **David Isaacson**, Rensselaer Polytechnic Institute, Mathematics Department, Troy, NY 12180, **Gary Saulnier**, Rensselaer Polytechnic Institute, Electrical Engineering Department - JEC, Troy, NY 12180, and **Jon Newell**, Rensselaer Polytechnic Institute, Biomedical Engineering Dept - 7049 JEC, 110 8th St., Troy, NY 12180. *Comparisons of reconstruction methods in electrical impedance tomography on a mammography geometry.*

We present a comparison among several reconstruction methods in electrical impedance tomography on a 60 electrode system arranged in a mammography geometry. The data was collected using the ACT4 system developed at RPI. The methods in the comparison include Calderon's approach, a one-step Newton's method, and an iterative Newton implementation using both the average-gap and the complete electrode models. An implementation of the finite element method allows for an iterative approach and for improved modeling of the domain shape. (Received September 21, 2009)

1056-65-1223 **Md Shafiqul Islam*** (mdshafiqul@yahoo.com), Department of Mathematics, University of Dhaka, Dhaka, 1000, Bangladesh. *Numerical solutions of fourth order boundary value problems using Bernoulli polynomials.* Preliminary report.

The aim of this talk is to find the numerical solutions of the fourth order linear and nonlinear boundary value problems using piecewise Bernoulli polynomials. We derive the Bernoulli polynomials explicitly over the interval [0, 1] to satisfy the given boundary conditions. To the knowledge of the author's, none has used these polynomials to solving differential equations so far. These polynomials can be differentiated and integrated easily, and are thus treated as linear combination to the approximate solutions in the Galerkin weighted residual method. Details mathematical formulation is provided to describe how these polynomials are used to obtain highly accurate solutions to the BVP. All the formulas are verified through numerical examples. The obtained approximate solutions are compared with the exact solutions, and with the solutions of the existing methods. It is found that if we increase the number of polynomials, the approximate solutions converge to the exact solutions monotonically even with desired large significant digits. (Received September 21, 2009)

1056-65-1280 **Livinus U Uko*** (luko@jcsu.edu), Department of Science and Mathematics, Johnson C Smith University, 100 Beatties Ford Road, Charlotte, NC 28216. *On the convergence of a generalized modified Newton scheme.* Preliminary report.

We use the Kantorovich theorem and the contraction mapping theorem to prove the convergence of the generalized modified Newton scheme

$$f'(u_0)u_{m+1} + g(u_{m+1}) = f'(u_0)u_m - f(u_m), \quad m = 0, 1, \ldots$$

for the solution of the nonlinear equation

$$f(u) + g(u) = 0.$$

We also discuss some possible applications of this iterative scheme. (Received September 21, 2009)

1056-65-1298 **Yanlai Chen***, 182 George St., Brown University, Box F, Providence, RI 02912, and **Jan S. Hesthaven** and **Yvon Maday**. *Reduced Basis Element Method for 2D Maxwell's Problem.*

We present a reduced basis element method (RBEM) for the time-harmonic Maxwell's equation. The RBEM is Reduced Basis Method (RBM) with a particular parameter, that is, the geometry of the computational domain, coupled with domain decomposition method. The basic idea is to first decompose the computational domain into a series of subdomains that are deformed from several reference domains; then to associate with each reference domain precomputed solutions to the same governing partial differential equation, but with different choices of deformations; finally to seek the approximation on a new shape as a linear combination of the corresponding precomputed solutions on each subdomain. Unlike the pioneering work on RBEM for thermal fin and fluid flow problems, we do not need a mortar type method to "glue" the various local functions. This "gluing" is done "automatically" thanks to the discontinuous Galerkin method we are using. We present the rationale of the method together with numerical results showing exponential convergence. Some theoretical techniques for the *a posteriori* error estimate for RBEM are also discussed. (Received September 21, 2009)

1056-65-1301 **Amelia McNamara*** (amcnamar@macalester.edu), **Jordan Seering** (seeri002@umn.edu) and **Yi Zeng** (yizeng2@illinois.edu). *Model and Optimization of Organic Photovoltaic Cells.*

This project focuses on optimizing the organic photovoltaic cell, an important topic in the energy industry which has not been well studied. We are especially interested in the optimization of the two active layers in the solar cell, the PEOPT polymer and the $C_{60}$ (Fullerene) layer. Using a numerical scheme (the finite difference method) we solve the diffusion equation of excitons in the one dimensional case, and implement it with two different accepted models of energy dissipation. This allows us to compare the exciton density and flux across the heterojunction between active layers which each model produces. Using our preferred model, we optimize the layer thicknesses of the two active layers, PEOPT and $C_{60}$, and determine them to be 12 $nm$ and 40 $nm$, respectively. We extend our analysis to a two-dimensional case including a curved boundary at the donor-acceptor heterojunction, using the simpler model, and study the effect of such a boundary on the conversion efficiency.
This project reports on results obtained during the 2009 Institute for Mathematics and its Applications (IMA) Interdisciplinary Research Experience for Undergraduates. (Received September 21, 2009)

1056-65-1345 **Andrew Christlieb**, **Maureen Morton*** (mortonm5@msu.edu) and **Jing-Mei Qiu**. *Higher order Strang split integral deferred correction methods for Vlasov equations.* Preliminary report.

We present arbitrary order time integration methods combined with Strang splitting and their application to the Vlasov equations within a semi-Lagrangian framework. These integral deferred correction (IDC) methods promise to be accurate and efficient time integrators because they easily extend simple lower order methods to higher order schemes by correcting provisional solutions. The goal is to determine the benefits and limitations of a higher order split time integrator obtained with the IDC framework in a semi-Lagrangian setting. The principles in this work can be extended to other operators suitable for splitting methods, such as Maxwell's equations. (Received September 21, 2009)

1056-65-1418 **Sean Cohen*** (secohen@ncsu.edu), Department of Mathematics, SAS Hall, 2311 Stinson Drive, Raleigh, NC 27695-8205, and **Alina Chertock**, **V. A. Trofimov** and **I. A. Shirokov**. *Computing Laser Ablation by a Finite-Volume Method.*

In this paper we consider the computation of laser ablation as presented in (Kuzyakov, Trofimov, Shirokov, Technical Physics, 2008). In laser ablation, a laser pulse strikes a solid material thereby causing fast evaporation of the target material. Efficient computation is important since the physical experiments are difficult to implement. The computation of laser ablation presents difficulties to numerical schemes. In the spatial domain, shocks are present. Finite difference schemes require an extremely large spatial domain to accurately resolve shocks. Explicit ODE solvers, such as the forward Euler method, require a time step of order $(\Delta x)^2$. The result is a high numerical cost, even for the 1-D problem. It is prohibitive when computing 2-D problems. In this paper, we apply a high-resolution finite-volume method to the problem. The method used is the central-upwind scheme developed in (Kurganov, Tadmor, Journal of Computational Physics, 2000). The scheme is able to produce the results at extensive computational savings while accurately resolving the shocks. (Received September 21, 2009)

1056-65-1445 **Martin Gander** (gander@math.unige.ch), Section de Mathématiques, Université de Genève, CP 64, CH-1211 Geneva, Switzerland, **Sébastien Loisel** (loisel@math.unige.ch), Section de Mathématiques, Université de Genève, CP 64, CH-1211 Geneva, Switzerland, and **Daniel B Szyld*** (szyld@temple.edu), Department of Mathematics, Temple University (038-16), 1805 N. Broad Street, Philadelphia, PA 19122. *Very fast methods and preconditioners for banded matrices and PDEs on irregular domains.*

Optimized Schwarz methods (OSM) and preconditioners subdivide the domain of a partial differential equation (PDE) into subdomains and use Robin transmission conditions at the artificial interfaces, and the Robin parameter can be optimized so that the resulting iterative method has an optimal convergence rate.

We present a completely algebraic view of OSM, including an algebraic approach to find the optimal operator or a sparse approximation thereof. This allows us to apply this method to any banded or block banded linear system of equations, and in particular to discretizations of PDEs on irregular domains.

With the computable optimal operator, we prove that the OSM converges in two iterations for the case of two subdomains. Similarly, we prove that when we use an Optimized Schwarz preconditioner with this optimal parameter, the underlying minimal residual Krylov subspace method converges in two iterations. Very fast convergence is attained even when the optimal operator is approximated by a sparse transmission matrix.

Numerical examples illustrating these results both for the additive and multiplicative case are presented. (Received September 21, 2009)

1056-65-1490 **Yingda Cheng*** (ycheng@math.utexas.edu), Dept. of Mathematics, Univ. of Texas at Austin, Austin, TX 78712, and **Irene M Gamba**, **Armando Majorana** and **Chi-Wang Shu**. *A Discontinuous Galerkin Solver for Full-Band Boltzmann-Poisson Models.*

In this talk, I will present some of the recent work on the discontinuous Galerkin solvers applied to deterministic computations of the transients for the Boltzmann-Poisson system describing electron transport in semiconductor devices. Full band models are accurate physical descriptions of the energy-band function. They are widely used in DSMC simulators, but only recently the transport Boltzmann equation was considered. We report simulations based on very general band structures. Preliminary benchmark numerical tests on Kane and silicon full band models are provided. (Received September 22, 2009)

1056-65-1507 **Li-Lian Wang*** (lilian@ntu.edu.sg), Division of Mathematical Sciences, School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore, 637371, Singapore. *Efficient High-Order Methods Using Bandlimited Basis Functions.*

Algebraic polynomials have been a major tool for numerical approximations, in this talk, we shall introduce an alternative apparatus for high-order approximations, which enjoys some notable advantages over the polynomial counterparts. Basically, we shall propose spectral/spectral element methods using bandlimited basis function, i.e., the prolate spheroidal wave functions. The use of such bases leads to quasi-uniform grids and enhances the resolution. As some applications, we shall develop efficient prolate spectral element methods for PDEs on the sphere, where the gridding on the sphere is based on the cubed-sphere transform. We shall present various numerical examples of PDEs for texture synthesis, phase-transition and geophysical applications. We shall also report some fundamental approximation results. (Received September 22, 2009)

1056-65-1548 **Roland Griesmaier*** (griesmai@math.udel.edu), 501 Ewing Hall, University of Delaware, Newark, DE 19716-2553. *Reconstruction of thin tubular inclusions in three-dimensional domains using electrical impedance tomography.*

We consider the inverse problem of reconstructing thin tubular inclusions inside some three-dimensional body from measurements of electrostatic currents and potentials on its boundary. By inclusions we mean objects with an electrical conductivity differing from that of the background material of the body. Potential applications are, e.g., the detection of shrinkage defects in castings in non-destructive testing or the reconstruction of buried wires or tubes in subsurface imaging.

Applying an asymptotic expansion of the electrostatic potential on the boundary of the body as the thickness of the inclusions tends to zero we establish an asymptotic characterization of the inclusions in terms of the measurement data. This characterization is implemented in a non-iterative reconstruction method similar to the linear sampling method and the factorization method for crack detection problems in two-dimensional domains. We present numerical examples to illustrate our theoretical findings and to highlight the potentials and limitations of our method. (Received September 22, 2009)

1056-65-1623 **Wei Wang*** (weiwang1@stanford.edu), 119 Quillen Ct, Apt 1015, Stanford, CA 94305, and **Johnny Guzmán** and **Chi-Wang Shu**. *The Multiscale Discontinuous Galerkin Method for Solving a Class of Second Order Elliptic Problems with Rough Coefficients.*

We develop a multiscale discontinuous Galerkin method for solving a class of second order elliptic problems. The main ingredient of this method is to use a non-polynomial multiscale approximation space in the DG method to capture the multiscale solutions using coarse meshes without resolving the fine scale structure of the solution. Theoretical proofs and numerical examples will be shown both in one and two dimensions. (Received September 22, 2009)

1056-65-1713 **Edward W. Swim*** (edward.swim@usma.edu), Department of Mathematical Sciences, United States Military Academy, 646 Swift Rd., West Point, NY 10996-1905. *Delaunay refinement methods for FSI systems undergoing changes in topological properties.* Preliminary report.

A key component of modeling the interaction between flexible structures that either surround a region of fluid (as with blood flow through arteries) or are immersed within an ambient fluid (such as flexible wing structures for micro air vehicles and canopies used for parachutes) is the simulation of the behavior of the system whenever structural components are in intermittent contact or very close to a contact configuration. In such situations, the topological properties of the computational fluid domain change. Thus, a modification of the assumptions within the dynamic fluid model is required.

In order to mimic the opening and closing of thin elastic structures during such a simulation, the mesh movement scheme must preserve the physical nature of the flexible structure and accurately represent the changing boundaries between the fluid and solid subdomains. In this work we discuss a method for protecting these boundaries at each step of a fluid-structure interaction simulation through the use of a ball covering strategy that translates to a weighted Delauney triangulation. Our procedure builds upon the DelPSC algorithm of Dey and Levine by extending their work with piecewise smooth complexes to include moving boundaries. (Received September 22, 2009)

1056-65-1716 **Jie Shen*** (shen7@purdue.edu), Department of Mathematics, Purdue University, West Lafayette, IN 47907. *An Efficient Spectral Method for Acoustic Scattering from Rough Surfaces.*

An efficient and accurate spectral method is presented for scattering problems with rough surfaces. A probabilistic framework is adopted by modeling the surface roughness as random process. An improved boundary perturbation technique is employed to transform the original Helmholtz equation in a random domain into a stochastic Helmholtz equation in a fixed domain. The generalized polynomial chaos (gPC) is then used to discretize the random space; and a Fourier-Legendre method to discretize the physical space. These result in a highly efficient and accurate spectral algorithm for acoustic scattering from rough surfaces. Numerical examples are presented to illustrate the accuracy and efficiency of the present algorithm. (Received September 22, 2009)

1056-65-1780 **Ali S shaqlaih*** (ashaqlaih@ou.edu), 500 NE 23RD AVE, NORMAN, OK 73071, and **Luther White** and **musharraf zaman**. *Resilient Modulus Modeling with information theory approach.*

The situation presents itself when one has data and many candidate models and the question is how to choose the best model that model the information in the data?In this talk Statistical models have been developed to correlate resilient modulus with routine properties of subgrade soils. An information theory approach is taken as a method in deciding the best model. This approach is compared with $R^2$ 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. Important results are captured and compared to the results of the $R^2$ method in two different data sets. (Received September 22, 2009)

1056-65-1781 **Charles N. Cook*** (cncook88@gmail.com), 1203 19th St, Port Huron, MI 48060, and **Maria Emelianenko**. *Numerical Study of a Quantum Memory Model.* Preliminary report.

Quantum computers have the potential to be much more powerful than their classical counterparts. However, there are still many obstacles that need to be overcome before quantum computing can become a viable tool, including problems related to storing information in quantum memory. One particular quantum memory model-a lambda-type three-level quantum system-aims to be more manipulable than other current models while also retaining information longer. Since this model can be computationally expensive, this study uses several different methods to simulate this model.

Results from specific cases of the model show that-given enough time-several methods, such as numerical schemes and exact solutions requiring numerical integration, are able to simulate the evolution of the quantum system according to theoretical predictions. An error analysis of each case compares the accuracy between the different approaches.

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1056-65-1802 **Joseph M Teran*** (jteran@math.ucla.edu), Mathematics Department, UCLA, Box 951555, Los Angeles, 90095-1555. *Virtual Surgery: Scientific Computing in Real Time.*

As a general rule, scientific computing for solid and fluid mechanics is regarded an offline task, often requiring days of CPU time to complete. However, it is now evident that future microprocessors will be highly parallel, incorporating a large number of cores with multi-threading and vector processing capabilities. This revolution in architecture will afford future chips the computational capacity found in today's massive clusters. Unfortunately, realization of this potential revolution in computing power is contingent upon the ability of numerical algorithms to successfully leverage the raw capacity of these parallel multiprocessors. This task is non-trivial given the nascent state of the architecture. Although the computing environment will resemble traditional high-performance computing, multi-core hardware will be sufficiently different to prevent simple porting of existing techniques from parallel computing. Novel approaches are needed that leverage the mathematical nuances of the various governing equations to meet the memory and scalability constraints of the hardware. I will discuss ongoing challenges developing such techniques and the potentially revolutionary applications they will admit. (Received September 22, 2009)

1056-65-1849 **Thomas F. Russell*** (trussell@nsf.gov), Office of Integrative Activities, National Science Foundation, 4201 Wilson Blvd., Suite 1270, Arlington, VA 22230.
*Eulerian-Lagrangian methods for multiphase multicomponent transport.*

Transport in porous media is often advection-dominated. This leads to efforts to incorporate Lagrangian techniques into numerical schemes, in order to overcome CFL limitations, numerical dispersion, and non-physical oscillations. In multiphase transport, these efforts are made easier by working with an adjoint system, whose natural interpretation is in terms of mass movement rather than wave propagation. The talk will explain this in the context of Eulerian-Lagrangian methods for multiphase multicomponent transport and will outline some recent developments. (Received September 22, 2009)

1056-65-1873 **Younbae Jun*** (yjun@uwa.edu), University of West Alabama, Department of Mathematics, Station 7, Livingston, AL 35470. *Domain decomposition method for solving three-dimensional parabolic partial differential equations.*

A non-overlapping domain decomposition algorithm to solve three-dimensional parabolic partial differential equations is presented. It has been shown in this paper that the algorithm is unconditionally stable and efficient. Intuitively we would think that the computation time on the interface would have been a very small fraction, because the size of the linear system for the interface is in general much smaller than that of the system for the interior. Unlike two-dimensional problem, it has been found out that estimating the values of the points of the interface in three-dimensional problem is no longer negligible. This phenomenon is analyzed by spectral radii for the interface and interior region. (Received September 22, 2009)

1056-65-1916 **Glenn Steven Young*** (younggs@jmu.edu), 1801A Putter Court, Harrisonburg, VA 22801, and **Anthony L Tongen**, **Nina Bence** and **Corey Cleland**. *Mathematical Modeling of Tail Movement.*

Our research focused on quantifying the relationship between stimulus location and withdrawal reflex in spinalized rats' tails. Using a system of differential equations, we modeled the tail as an eleven-segment spring-mass system, with the length, mass, spring constants, and damping coefficients determined experimentally. We then solved the system of differential equations numerically to reproduce the behavior of the tail. The numerical method implemented was developed by Ed Parker and Jim Sochaki at James Madison University, and uses a modification of Picard's method to produce the power series solution. (Received September 22, 2009)

1056-65-1945 **Patrice Koehl*** (koehl@cs.ucdavis.edu), Genome Center, Room 4319, GBSF Building, University of California, Davis, Davis, CA 95616, and **Joel Franklin**, **Sebastian Doniach** and **Marc Delarue**. *Fast Protein Dynamics Simulations: Dominant Pathways for Protein Conformational Transitions.* Preliminary report.

Both structural and dynamical properties of macromolecules are essential to understand and account for their biological functions. There are numerous examples of biologically important structural rearrangements, including allosteric dynamics of receptors that undergo a transition from an open to a closed state upon ligand binding. While experimental methods can give an atomic description of the two end states, they cannot describe the transition itself. Most studies of structural transitions rely on simulation techniques such as molecular dynamics, but the time scale accessible to such methods is several orders of magnitude smaller than the time scale during which these phenomena occur. Our solution to the problem of finding a path between two states of a molecule is to reformulate the Langevin equation that describes the dynamics as an action minimization problem. We show that this formulation leads to large systems of differential equations that can be efficiently solved using Krylov subspace methods for approximation the product of a function of a matrix times a vector. We perform an illustrative application of these ideas on the dynamics of ion channels in cell membranes. (Received September 22, 2009)

1056-65-1959 **Chensong Zhang*** (zhangcs@psu.edu), Math Dept, Penn State Univ, State College, PA 16802, and **Long Chen** (chenlong@math.uci.edu), Department of Mathematics, University of California at Irvien, Irvine, CA 92617. *A COARSENING ALGORITHM ON ADAPTIVE GRIDS BY NEWEST VERTEX BISECTION AND ITS APPLICATIONS.*

An efficient and easy-to-implement coarsening algorithm is proposed for adaptive grids obtained using the newest vertex bisection method in two space dimensions. The coarsening algorithm does not require storing the binary refinement tree explicitly. Instead, the struc- ture is implicitly contained in the special ordering of triangular elements. This not only reduces the memory usage and CPU time, but also simplifies the implementation.

Numerical experiments demonstrate that the proposed coarsening algorithm is very efficient when applied for multilevel preconditioners and mesh adaptivity for time-dependent problems. (Received September 22, 2009)

1056-65-1962 **Joshua D. Snyder*** (jsnyderb@gmu.edu), 800 South State Street, Ephrata, PA 17522. *Analysis of 3D Potts Model Monte Carlo Simulation of Crystalline Grain Growth.*

The Potts Model Monte Carlo simulation is one of the most popular tools for modeling grain growth in polycrystalline materials. Better understanding of how materials crystallize can help improve the quality of materials products and will lead to more efficient engineering techniques. The way the grains are connected to each other through a network of grain boundaries, called microstructure, and the types of such boundaries, determine how materials behave on the macro-scale. The goal of this work is to analyze coarsening rates during microstructure evolution and identify key factors that influence them. In particular, we want to be able to predict the times when new crystals appear, or when old ones disappear, and to track the topological changes of the grain network. We explore the connections between the statistical distributions for various types of microstructures and compare the Monte Carlo model with other models of grain growth. (Received September 22, 2009)

1056-65-1963 **Yuen Yick Kwan*** (tkwan@tulane.edu), 1322 West Esplanade Ave, apt N, Kenner, LA 70065. *Simulation of Surfactant Dynamics using Spectral Method.* Preliminary report.

The coupling between a bulk vortical flow and a surfactant-influenced interface in a stationary open cylinder driven by the constant rotation of the bottom disk is investigated. The time-discretized equations are solved using an efficient and effective spectral-Galerkin method recently developed. It is found through numerical simulation that the base axisymmetric flow is unstable to three-dimensional perturbations for sufficiently large rotation rates. (Received September 22, 2009)

1056-65-1973 **Christopher M Kuster*** (ckuster@carrollu.edu), Department of Mathematics, Carroll University, 100 N East Ave, Waukesha, WI 53186. *An optimization-based approach to discretizing the eikonal equation.*

In numerical methods such as the Fast Marching Method, the eikonal equation ($|\nabla\phi| = 1$) is solved using a finite differences approach. The solution to this equation is the minimum distance to the given boundary. In this presentation, the standard first and second order discretizations are matched with equivalent minimization problems. In addition, a new method is proposed to solving the eikonal equation with a non-constant slowness function ($|\nabla\phi| = F(x)$). This method treats $F(x)$ as a piecewise quadratic function instead of the standard piecewise constant. (Received September 22, 2009)

1056-65-2033 **Michael Holst** (mholst@math.ucsd.edu), Department of Mathematics, University of California San Diego, La Jolla, CA 92093, **Gantumur Tsogtgerel** (gantumur@math.ucsd.edu), Department of Mathematics, University of California San Diego, La Jolla, CA 92093, and **Yunrong Zhu*** (zhu@math.ucsd.edu), Department of Mathematics, University of California San Diego, La Jolla, CA 92093. *Convergence of Adaptive Finite Element Methods for Nonlinear Partial Differential Equations.* Preliminary report.

In this talk, we present a convergence theory for a general class of adaptive approximation algorithms for abstract nonlinear operator equations on Banach spaces, and then use the theory to obtain convergence results for practical adaptive finite element methods (AFEM) applied to a large class of nonlinear elliptic equations. We develop a weak* convergence framework for nonlinear operators which are locally Lipschitz and satisfy a local inf-sup condition. The convergence result for the abstract adaptive algorithm is then applied to a sequence of examples using standard residual-type AFEM algorithms, a semilinear problem with polynomial nonlinearity, the steady Navier-Stokes equations, and a more general quasilinear problem. We also present a contraction framework for general semilinear elliptic PDEs, and give some examples. (Received September 23, 2009)

1056-65-2069 **Jia Liu*** (jliu@uwf.edu), Department of Mathematics and Statistics, 11000 University Pkwy, Pensacola, FL 32514. *HSS preconditioning techniques for the Navier-Stokes equations.* Preliminary report.

This presentation is concerned with the solution of steady-state incompressible flow problems using MAC discretizations and preconditioned Krylov subspace methods. Our emphasis is on preconditioners that can be thought of as approximate block factorizations of the discretized equations. Several such preconditioners for the Stokes and Oseen (linearized Navier–Stokes) problems in two and three dimensions are described and experimentally compared. Linearization and application of an implicit time steeping scheme results in a linear stationary problem of Oseen type. Resutls of several preconditioners for steady Oseen problem and unsteady

Oseen problem are presented which illustrate HSS (Hemittion and Skew-Hemittion) preconditioner behaves best. (Received September 23, 2009)

1056-65-2073 **James V Lambers*** (James.Lambers@usm.edu), Department of Mathematics, University of Southern Mississippi, 118 College Dr #5045, Hattiesburg, MS 39406-0001. *A Spectral Time-Domain Method for Computational Electrodynamics.* Preliminary report.

The finite-difference time-domain method has been a widely-used technique for solving the time-dependent Maxwell's equations. This talk presents an alternative approach in the case of spatially-varying coefficients, based on Krylov subspace spectral (KSS) methods. KSS methods for scalar time-dependent PDE compute each Fourier coefficient of the solution using techniques developed by Golub and Meurant for approximating elements of functions of matrices by Gaussian quadrature in the spectral domain. We show how they can be generalized to systems of equations, such as Maxwell's equations, by choosing appropriate basis functions. We also discuss the implementation of appropriate boundary conditions. (Received September 23, 2009)

1056-65-2078 **Kanagaratnam Arunakirinathar*** (aruna@ukzn.ac.za), Howard College Campus, Durban, 4001, South Africa. *Interpolation error estimates for hexahedral finite elements: geometrical approach.*

A hexahedral finite element may be regarded as a perturbation of its associated equivalent parallelipiped, which has very interesting geometrical properties. Using its equivalent parralelipiped, I define a regular family of hexahedral finite elements. This definition is used together with other properties to obtain in a relatively simple manner estimates, in appropriate seminorms or norms, of the isoparametric map and its Jacobian, for use in the determination of finite element interpolation error estimates. (Received September 23, 2009)

1056-65-2123 **M. Zuhair Nashed*** (znashed@mail.ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816. *Moment Problems in Reproducing Kernel Hilbert Spaces.*

The problem of recovery or estimation of a function from its moments arises in several areas of the geosciences. Seminal contributions in this context have been made by Backus and Gilbert, Sabatier, and others. In this talk, I will provide new perspectives on the Backus-Gilbert method for the numerical moment problem. The incorporation of a priori information about the signal and the the sense of approximation of the delta function by various delta sequences and in different Sobolev spaces of negative norms give rise to interesting optimizational and numerical analysis problems. We also consider connections between average sampling and the problem of reconstruction of a signal from its momemts. We explore some of these aspects in particular for signals belonging to reproducing kernel Hilbert spaces. (Received September 23, 2009)

1056-65-2138 **Daniela Calvetti*** (dxc57@case.edu), Department of Mathematics, 10900 Euclid Avenue, Cleveland, OH 44106, and **Erkki J. Somersalo**. *Bayesian Scientific Computing.*

In many computational problems where the data is scarce and of poor, augmenting standard algorithms with available qualitative information about the sought solution may dramatically improve the results. In this talk we outline how to recast some classes of computational problems within a Bayesian framework while retaining algorithmic efficiency. In addition to showing how this approach can be used to assess the reliability of the results, we will discuss how the the weight of the prior is a function of the quality of the data. The results of some computed examples arising from imaging applications will be presented. (Received September 23, 2009)

# *68 ► Computer science*

1056-68-121 **G. Beate Zimmer*** (beate.zimmer@tamucc.edu), Texas A&M University-Corpus Christi, Dept. of Math and Statistics, Unit 5825, 6300 Ocean Drive, Corpus Christi, TX 78412-5825, **Reid Porter** (rporter@lanl.gov), Los Alamos National Laboratory, Los Alamos, NM 87544, and **Don Hush**, Los Alamos National Laboratory, Los Alamos, NM 87544. *Stack filter classifiers with an application to change detection in images.*

While stack filters are usually used for filtering signals, we propose to use them for a classifier. Stack filters are induced by threshold decomposition and a Positive Boolean Function. This function acts on binary strings generated by thresholding the input sample vector by each component of the sample vector. The training of such a classifier consists of finding a positive Boolean function that minimizes the training loss. The decision region is found by growing hyperrectangles around training samples and resolving overlaps between hyperrectangles of different classes. We define training loss in terms of a hinge loss that measures how far each training sample is inside a region of the correct or the wrong class. The optimization uses a regularization which makes it a quadratic programming problem. As an application we use this classifier to distinguish between 'normal' changes in pixel values between two images of the same scene and anomalous changes. (Received July 28, 2009)

1056-68-440 **Facundo Memoli*** (memoli@math.stanford.edu), Stanford University, Mathematics Department, Building 380, Sloan Hall, Stanford, CA 94305. *A spectral notion of Gromov-Wasserstein distances.*

We introduce a spectral notion of distance between shapes (closed Riemannian manifolds) and study its theoretical properties. We show that our distance satisfies the properties of a metric on the class of isometric shapes, which means, in particular, that two shapes are at 0 distance if and only if they are isometric. Our construction is similar to the Gromov-Wasserstein distance, but rather than viewing shapes as metric spaces, we define our distance via the comparison of heat kernels. This is possible since the heat kernel characterizes the shape up to isometry. By establishing two different hierarchies of lower bounds, we relate our distance to previously proposed spectral invariants used for shape comparison, such as the spectrum of the Laplace-Beltrami operator and statistics of pair-wise diffusion distances. Lower bounds in these hierarchies provide increasing discriminative power at the expense of more involved computations. (Received September 07, 2009)

1056-68-662 **Zachary T. Harmany**, Duke University, **Roummel F. Marcia*** (rmarcia@ucmerced.edu), University of California, Merced, 5200 North Lake Road, Merced, CA 95343, and **Rebecca M. Willett**, Duke University. *This is SPIR̈AL TAP: Sparse Poisson intensity reconstruction algorithms (theory and practice).*

The observations in many applications consist of counts of discrete events, such as photons hitting a dector, which cannot be effectively modeled using an additive bounded or Gaussian noise model, and instead require a Poisson noise model. As a result, accurate reconstruction of a spatially or temporally distributed phenomenon ($f$) from Poisson data ($y$) cannot be accomplished by minimizing a conventional $l_2 - l_1$ objective function. This talk the estimation of $f$ from $y$ in an inverse problem setting, where (a) the number of unknowns may potentially be larger than the number of observations and (b) $f$ admits a sparse approximation in some basis. The optimization formulation we consider uses a negative Poisson log-likelihood objective function with nonnegativity constraints (since Poisson intensities are naturally nonnegative). We describe computational methods for solving the constrained sparse Poisson inverse problem. In particular, we propose an approach that incorporates key ideas of using quadratic separable approximations to the objective function at each iteration and computationally efficient partition-based multiscale estimation methods. (Received September 15, 2009)

1056-68-853 **Santosh S Vempala*** (vempala@cc.gatech.edu) and **S Charles Brubaker**. *Affine-invariant Principal Components.*

Principal component analysis (PCA) is widely used to identify important directions or subspaces. For a given data set or distribution, PCA can be identified with a particular affine transformation. In this talk, we discuss a notion of principal components which is affine-invariant. We apply this extension of PCA to a classical problem from statistics, namely unraveling a mixture of arbitrary Gaussian distributions in high-dimensional space given unlabeled samples from the mixture. We will discuss the method in the context of other known methods for dimension reduction and show how it complements them.

This is joint work with Charlie Brubaker. (Received September 18, 2009)

1056-68-908 **Andrzej Czygrinow*** (Andrzej.Czygrinow@asu.edu), School of Math and Stat Sciences, Tempe, AZ 85287. *Distributed algorithms and graph theory.*

IIn this talk we will discuss connections between graph theory and the theory of distributed algorithms. We will focus on two classes of graphs, planar graphs and graphs of bounded arboricity, and analyze the distributed complexity of some of the classical optimization problems. Among other result we indicate how to use graph-theoretic tools, like Ramsey theory, to obtain lower bounds for distributed complexity of some problems. (Received September 18, 2009)

1056-68-1303 **Chris Umans*** (umans@cs.caltech.edu), Computer Science MC 305-16, California Institute of Technology, Pasadena, CA 91125. *Group-Theoretic Algorithms for Matrix Multiplication.*

I'll outline a group-theoretic approach to devising fast algorithms for matrix multiplication, developed by H. Cohn, R. Kleinberg, B. Szegedy and myself in papers appearing in FOCS 2003 and FOCS 2005. In this framework, one devises algorithms for matrix multiplication by constructing finite groups with certain properties. The algorithms themselves are easy to describe, and they make critical use of the Discrete Fourier Transform over non-abelian groups.

I'll outline some progress toward an improved algorithm using this new approach and state a self-contained conjecture that would lead to an essentially optimal nearly-quadratic algorithm. (Received September 21, 2009)

1056-68-1536 **Partha Niyogi*** (niyogi@cs.uchicago.edu), 1100 E. 58th Street, Ryerson 167, Chicago, IL 60637. *A Geometric Perspective on Learning Theory and Algorithms.*

Increasingly, we face machine learning problems in very high dimensional spaces. We proceed with the intuition that although natural data lives in very high dimensions, they have relatively few degrees of freedom. One way to formalize this intuition is to model the data as lying on or near a low dimensional manifold embedded in the high dimensional space. This point of view leads to a new class of algorithms that are "manifold motivated" and a new set of theoretical questions that surround their analysis. A central construction in these algorithms is a graph or simplicial complex that is data-derived and we will relate the geometry of these to the geometry of the underlying manifold. Applications to embedding, clustering, classification, and semi-supervised learning will be considered. (Received September 22, 2009)

1056-68-2149 **Vin de Silva*** (vin.desilva@pomona.edu), Department of Mathematics, Pomona College, 610 N College Ave, Claremont, CA 91711-4411. *From Isomap to Persistence: nonlinear dimensionality reduction with circular coordinates.*

Nonlinear dimensionality reduction (NLDR) is the art of discovering low-dimensional coordinate embeddings of high dimensional data; the hope is that the the new coordinates reveal low-dimensional intrinsic structure that might not be easily recognised in the original coordinates. Algorithms for NLDR include Isomap, LLE, Laplacian Eigenmaps, Hessian Eigenmaps, and many more.

The limitation of these techniques is the inherent assumption that the data *can* be usefully embedded in low dimensional Euclidean space. In particular, it is usually assumed that the data can be represented as a convex coordinate patch in Euclidean space. In particular, data sets with the topology of a circle or torus are not well handled.

I will discuss recent work with Mikael Vejdemo Johansson and Dmitriy Morozov which extends the NLDR framework to a search for low-dimensional coordinates which are circle-valued (rather than real-valued). We use the machinery of topological persistence, specifically persistent cohomology, to identify 1-cocycles and represent them as smooth circle-valued functions on the data. This appears to give good results for simple data spaces with nontrivial topology. (Received September 23, 2009)

# *70 ► Mechanics of particles and systems*

1056-70-972 **Josep Cors**, **Glen R. Hall** and **Gareth E. Roberts*** (groberts@radius.holycross.edu), Dept. of Mathematics and Comp. Sci., 1 College Street, College of the Holy Cross, Worcester, MA 01610. *Cyclic Central Configurations in the Four-Body Problem.* Preliminary report.

For the Newtonian 4-body problem, we study the set of convex central configurations that lie on a common circle. Such a configuration will be referred to as a *cyclic central configuration* (ccc). A central configuration is a special choice of positions where the gravitational force on each body is a scalar multiple of that body's position. Such a configuration leads to both homothetic and homographic periodic solutions in the $n$-body problem. Analytic, numerical and geometric results will be presented. Two symmetric families, the kite and isosceles trapezoid, are investigated extensively. We conjecture that if a ccc exists for a particular choice of masses, then it is unique. (Received September 19, 2009)

1056-70-1372 **David A Long*** (dalong@ncsu.edu), **Anthony M Bloch**, **Jerrold E Marsden** and **Dmitry V Zenkov**. *Relaxed Matching for the Method of Controlled Lagrangians.*

The method of controlled Lagrangians is a technique for stabilizing relative equilibria of mechanical systems with symmetry. The idea is to modify the kinetic energy in such a way that the new terms in the equations of motion introduced by this modification can be viewed as the control inputs in the original system. We show that the hypotheses required by this method can be relaxed, making it applicable to a broader class of systems. We demonstrate this new method, called "relaxed matching," with the problem of the pendulum on a rotor arm. (Received September 21, 2009)

1056-70-1432 **Ahmed Kaffel*** (kaffel@math.vt.edu), 1404 J university city boulevard, blacksburg, VA 24060, and **Amel Soualmia** and **Masbernat Lucien**. *Closure of a Saint Venant model for free surface flows on an open channel with cross stream variation of the bottom roughness.*

In this study we analyzed the effects of secondary flows on the transverse distribution of the depth average velocity in free surface flows above non-uniform bottom roughness. In a first preliminary step, 3D-simulations were achieved using an anisotropic algebraic Reynolds stress model to determine the wall friction and the dispersion terms present in the depth averaged momentum equation. In a second and fundamental step closure assumptions of these terms were tested to define a 2D-Saint Venant model which is solved to calculate the transverse profile of the depth-averaged velocity. This approach was applied to opened channels with periodic transverse variation of the roughness with reference to some available experimental results. This process could allow analyze of scale change problems. Keywords: 2D-Saint Venant equations; wall friction; Secondary flows ; Roughness; free surface flows; Dispersion ; Turbulence (Received September 21, 2009)

# 74 ► Mechanics of deformable solids

1056-74-650 **Robert J Ronkese*** (bob.ronkese@usma.edu), Dept of Mathematical Sciences, United State Military Academy, West Point, NY 10996. *2-D Biharmonic Equation for the Displacement of an Isotropic Kelvin-Voigt Viscoelastic Plate.* Preliminary report.

The plate and the rod are two geometric solids than can be used to model the trabeculae of bone. Trabucho and Via no 1n 1996 and Figueiredo and Trabucho in 2004 have used the adaptive elastic rod to model the deposition and reabsorption, or remodeling, of trabecular bone. Gilbert and Ronkese in 2008 have formulated this for the case of the isotropic Kielvin-Voigt viscoelastic rod with numerical simulations of displacement and bone growth under loading. Recently, Ronkese has gone further to derive equations for a 2-D biharmonic equation for the displacent of an isotropic Kelvin-Voigt viscoelastic plate. Force balances involving the stress and strain tensors as well as a remodeling rate equation that depends on strain tensors will be presented. Asymptotic relastionships due to the thinness of the plate will be included. (Received September 15, 2009)

1056-74-699 **John A Pelesko*** (pelesko@math.udel.edu), 406 Ewing Hall, Department of Mathematical Sciences, Newark, DE 19716. *Notes from the MEC Lab at the University of Delaware.*

In the Department of Mathematical Sciences at the University of Delaware, we are fortunate to host an experimental laboratory. This lab, called the "MEC Lab," exists to help students, postdocs, and faculty experience the interplay between modeling, experiment, and computation. In this talk, we will describe recent experiments in electrostatic-solid interactions, fluid dynamics, and solidification, that are being conducted by undergraduate and graduate students. We will explain the mathematics associated with these experiments and how this work is incorporated into our courses and research programs. (Received September 16, 2009)

1056-74-2101 **David L Chopp*** (chopp@northwestern.edu), ESAM, Tech Institute, Northwestern University, 2145 Sheridan Rd., Evanston, IL 60208. *Simulation and validation of 3-dimensional fatigue cracks.*

In this talk we will describe a novel algorithm developed in collaboration with Global Engineering and Materials, Inc. to simulate fatigue cracks. The algorithm uses a combination of the eXtended Finite Element Method (X-FEM) and the Fast Marching Method (FMM) to compute the evolution of a two-dimensional crack surface inside an irregular 3-dimensional object. The simulations are run using geometries from actual airplane parts and comparisons are made between physical stress experiments and numerical simulations demonstrating the effectiveness of both the mathematical model and the numerical implementation to reliably assess risk of failure of stressed solid materials. (Received September 23, 2009)

# 76 ► Fluid mechanics

1056-76-178 **Andrea Bertozzi*** (bertozzi@math.ucla.edu), UCLA Department of Mathematics, 520 Portola Plaza, Los Angeles, CA 90095. *Mathematical theory of particle laden flow.*

Particle laden thin film flow is particularly complex to model as it involves microscale and macroscopic physics and moving contact lines. The author will present recent results from UCLA discussing both physical experiments of this problem and related mathematical theory and the mathematical challenges faced when trying to understand particle laden flow. (Received August 12, 2009)

1056-76-285 **Holly N. Clark*** (hclark@math.utk.edu) and **Tim P. Schulze**. *Multistep Kinetic Monte Carlo.* Preliminary report.

In general, Monte Carlo refers to a class of algorithms that solve problems using random numbers. Kinetic Monte Carlo (KMC) can be used to simulate the time evolution of processes with well-defined rates. We analyze a multi-step KMC algorithm aimed at speeding up the single-step procedure and apply the algorithm to study a model for the growth of a surface dendrite. The growth of the dendrite is initiated when atoms diffusing on a substrate cluster due to lower hopping rates for highly coordinated atoms. The boundary of the cluster is morphologically unstable when the flux of new atoms is supplied in the far field, a scenario that could be generated by masking a portion of a substrate that is subject to some kind of deposition process. We allow atoms far from the growing dendrite to take large hops while atoms near the dendrite follow a usual single-step KMC algorithm. We study how coarse-graining affects the distribution of waiting times for hops, and how to accurately couple the multi-step and single-step regions. (Received August 25, 2009)

1056-76-338 **Anna Zemlyanova*** (azem@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, and **Yuri Antipov**. *Application of the Riemann-Hilbert technique to a problem of a supercavitating wedge.*

Cavitation is an important aspect to consider for many industrial applications. However, the resulting mathematical problems present significant difficulties even in the two-dimensional ideal fluid case. In this talk we apply the methods of conformal mapping and Riemann-Hilbert problems on a Riemann surface to obtain a closed form solution of a problem for a non-symmetrical supercavitating wedge under free surface. The problem is reduced to a system of non-linear transcendental algebraic equations. Newton's method is employed for the solution of the system. The numerical results are presented. (Received August 30, 2009)

1056-76-472 **Ellen Peterson*** (erpeters@ncsu.edu), North Carolina State University, Box 8205, Raleigh, NC 27695, and **Michael Shearer** (shearer@ncsu.edu), North Carolina State University, Box 8205, Raleigh, NC 27695. *Spreading Surfactant on a Thin Liquid Layer.*

To model the spreading of a rotationally symmetric droplet of insoluble surfactant on a thin liquid layer, we use the lubrication approximation of the Stokes equations. The resulting system of nonlinear PDE describes the height of the fluid surface and the distribution of surfactant on the surface. The flow is driven by the surface tension gradient induced by the surfactant. Ignoring the smoothing effects of capillarity and diffusion of surfactant, the system simplifies to a pair of transport equations that have hyperbolic/parabolic type. These equations admit a similarity solution characterized by Jensen and Grotberg (1992) that sets the spreading rate of the surfactant layer. We employ finite difference simulations to capture the shape of the free surface and the surfactant distribution. For the full system, with capillarity, the smoothing effect of gravity, and diffusion on the surface, the leading shock smooths to a ridge clearly visible in experiments. We compare simulations of the full thin film system with experimental observations of film height profiles, and with the observed spreading rate of the surfactant layer, visualized using fluorescence. (Received September 09, 2009)

1056-76-737 **Stephen Childress*** (childress@cims.nyu.edu), 251 Mercer Street, New York, NY 10012. *Symmetry and locomotion in theory and experiment.*

Locomotion in fluids depends strongly upon the Reynolds number $Re$, and significant changes in the mechanisms of propulsion occur when $Re$ is in the intermediate range 10-100. In these cases analysis of flows is extremely difficult and experimentation, both numerical and physical, can play an essential role. We illustrate this by studying the onset of forward flapping flight as a mathematical bifurcation in a frequency Reynolds number. Observations of a antarctic pteropod, as well as a simple laboratory experiment, confirm this bifurcation for flapping bodies with fore-aft symmetry. Some recent experiments on hovering flight of asymmetric bodies in an oscillating ambient flow will also be described. (Received September 16, 2009)

1056-76-742 **Mulugeta Markos*** (mmarkos@ncwc.edu), 3324 Sunset Ave. Apt. E6, Rocky Mount, NC 27804. *Comparisons of Different Groove Structures in a Steady-Liquid Flow for Designing Efficient Micro Heat Pipes.*

In this paper steady-liquid flow and heat transfer in a micro heat pipe with triangular, rectangular and advanced capillary shaped grooves have been closely examined, to study the maximum heat transport capability of cooling devices such as micro heat pipes. A lubrication-type model of liquid flow and heat transfer under negligible gravity and small capillary number is considered. The adiabatic region plays an important role in determining the flow rate. The flow rate could be controlled by changing the shape of the cross-section. Heat transport capability of different groove structures is compared. The comparison has significant contribution in selecting the best groove structure for designing and improving performances of micro heat pipes. Practical applications of our results are discussed in relation to the design and optimization of micro heat pipes. (Received September 16, 2009)

1056-76-773 **Jared Debrunner*** (mailjared@gmail.com), Department of Computer Science, California State University, Chico, Chico, CA 95929, **Anton Mazurenko** (anton.mazurenko@gmail.com), Department of Physics, Massachusetts Institute of Technology, Cambridge, MA, **Brent Nelson** (brentnelson6@gmail.com), Department of Mathematics, University of Illinois at Urbana-Champaign, Urbana-Champaign, IL , and **Sergei Fomin** (sfomin@csuchico.edu), Department of Mathematics and Statistics, California State University, Chico, Chico, CA 95929. *Steady State Rimming Flow of non-Newtonian Fluid.*

Using a scale analysis and the method of perturbations, a theoretical description is obtained for the steady-state non-Newtonian flow on the inner wall of the rotating horizontal cylinder. The Maxwell upper-convective equation is chosen to model the visco-elastic properties of the fluid. In the general case, the derived governing equations are rather awkward and can be solved only numerically. However, since the polymeric solutes used in roto-molding and coating technologies exhibit the relatively weak elastic properties, the Deborah number for such flows is rather small (De<1). Exploiting this fact, the perturbation method is applied for simplification of the model. As a result, the first order non-linear differential equation for the thickness of the fluid film is derived. An approximate analytical solution of this equation is found. The accuracy of analytical solution is verified by the direct numerical solution of the derived equation. Using the obtained solutions, the criteria which guarantee the stable steady-state flow of the liquid polymer and the uniform final thickness of the coating film are determined. The bounds for the different flow regimes and principal controlling parameters are identified.
(Received September 17, 2009)

1056-76-961 **Longhua Zhao*** (zlh@email.unc.edu), CB#3250, Phillips Hall, Chapal Hill, 27514, and **Roberto Camassa** and **Richard M. McLaughlin**. *Flow structure of a sphere or spheroid immersed in shear flows in the Stoke's regime.*

Building on work by Wu and Chwang who developed closed form exact solutions of the Stokes for the case of a sphere or spheroid embedded in a linear shear layer, we study the structure of such flows and document rigorously that the blocking behavior which was observed by Wu and Chwang for the two dimensional case occurs in the fully 3D case well. We solve the explicit and analytic solution for the particle trajectories for this fully 3D flow and compute explicitly the volume of the blocking region, which is seen to be infinite. We explore cases when the sphere or spheroid have centers displaced from the background shear symmetry line. We document an interesting bifurcation in the particle trajectories using numerical techniques. (Received September 18, 2009)

1056-76-1105 **Chia Yu Hsu*** (chsu1@tulane.edu), 1643 Josephine St. Apt.210, New Orleans, LA 70130, and **Eric Tytell** and **Lisa Fauci**. *An integrated muscle mechanic-fluid dynamic model of lamprey swimming.*

In an effort towards a detailed understanding of the generation and control of vertebrate locomotion, including the role of the CPG and its interactions with reflexive feedback, muscle mechanics, and external fluid dynamics, we study a simple vertebrate, the lamprey. Lamprey body undulations are a result of a wave of neural activation that passes from head to tail, causing a wave of muscle activation. These active forces are mediated by passive structural forces. We present recent results from a model that fully couples a viscous, incompressible fluid with nonlinear muscle mechanics. We measure the dependence of the phase lag between activation wave and mechanical wave as a function of model parameters, such as body stiffness and muscle strength. Simulation results are compared to experiments utilizing both real and synthetic lamprey. (Received September 20, 2009)

1056-76-1284 **Michael Shearer*** (shearer@ncsu.edu), Department of Mathematics, NC State University, Raleigh, NC 27695-8205, and **Laura Golick**, **Lindsay H May** and **Karen E Daniels**. *Particle size segregation in granular flow.*

Granular materials tend to segregate by size, density, shape or material properties, when vibrated or sheared. In this talk, I discuss modeling, analysis and simulations of a simple model formulated in 2005 by Gray and Thornton to describe segregation by size of a mixture of two sizes of particles in an avalanche. To test the model, we conducted experiments in an annular (Couette) cell, with a movable bottom plate that is rotated to generate shear. In this circumstance, the Gray-Thornton equation is modified to accommodate non-uniform shear. The result is a fair comparison between theory and experiment, together with indications of how the model might be refined to incorporate some effects observed in the experiments but absent from solutions of the model equation.
(Received September 21, 2009)

1056-76-1493 **Ricardo Ortiz*** (ricardo.ortiz@tulane.edu), Tulane University, Center for Computational Science, 416 Stanley Thomas Hall, New Orleans, LA 70118, and **Ricardo Cortez**. *Simulation of flagellar motion near a rigid surface.*

We present a computational model for the simulation of Stokes flows generated by forces and torques close to a rigid plane and apply it to the study of the swimming motion of flagellated organisms near a rigid surface. The model is based on an extension of the method of regularized Stokeslets in which a regularization parameter provides the support of each force and torque exerted on the fluid by the organism, and eliminates the singularity of the velocity expressions. Forces exerted on the fluid by the organism are created from an elasticity model and the torques represent the effect of the rotary motor of the flagellum. We show two examples in which the flagellar bundle rotates with helical motion and another where the flagellum moves resembling a sine wave. (Received September 22, 2009)

1056-76-1537 **Thomas Dowd*** (dowd.thomas@gmail.com), 649 S. mason Street, Harrisonburg, VA 22801. *Shock Wave Formation on Turbulent Coanda Surfaces.*

In the petroleum industry a procedure called flaring is used, which is the burning off of unwanted gas. Modern day flares use the Coanda effect,which states "when a jet of fluid is passed over a curved surface it bends to follow the surface entraining large amounts of air" to achieve smokeless combustion, increased combustion efficiency, and decreased thermal radiation due to the entrainment of large amounts of air. These advantages are at the cost of increased noise pollution, due to shock wave formation caused by the difference in the nozzle exit pressure and the ambient pressure. Sound called Shock-Associated Noise is generated by the interaction of downstream propagating turbulent eddies and the stationary quasi-periodic shock-cell structure contained in the supersonic jet. A model of Shock-Associated Noise near turbulent Coanda surfaces will be presented, and compared with experimental data along with suggestions for reducing noise. Also a visualization of these shock wave formations and their intricacies will be presented if time allows. (Received September 22, 2009)

1056-76-1561 **Linda B. Smolka*** (lsmolka@bucknell.edu), 380 Olin Hall, Bucknell University, Lewisburg, PA 17837, and **Dennis Fillebrown**, **Bree Guerra** and **Justin North**. *Dynamics of Free Surface Perturbations Along an Annular Viscous Film Flowing Down a Vertical Fiber.*

The free surface of an axisymmetric viscous film flowing down the outside of a thin vertical fiber has been shown to become unstable to interfacial perturbations. We present an experimental and numerical study to investigate the early-time growth and dynamics of these perturbations. We find in experiments that the initial perturbation growth is exponential followed by a slower phase as the amplitude and wavelength saturate in size. We compare our experimental data and observations to linear stability analysis results and numerical simulations of a Stokes flow model (Craster & Matar, J. Fluid Mech. **553**, 85 (2006)). We also investigate in experiments a known transition in the longer-time perturbation dynamics from unsteady to steady behavior at a critical flow rate and show this transition is correlated to a transition in the rate at which perturbations naturally form along the fiber. (Received September 22, 2009)

1056-76-1703 **Lisa M Melanson*** (l-melanson@northwestern.edu), ESAM Department, Northwestern University, 2145 Sheridan Road, Evanston, IL 60208. *Numerical Modeling of Intracranial Aneurysms.* Preliminary report.

Intracranial aneurysms are highly prevalent in the general population and pose life-threatening health risks if left untreated. The rupture of these bulbous dilatations accounts for nearly 18,000 deaths per year in North America alone. Geometry of the blood vessels and wall shear stresses can lead to changes in the material properties of the arterial wall, allowing the aneursym to grow and potentially rupture. In this study, we examine a rigid arterial wall model to investigate how this remodeling is influenced by geometry and fluid stress. The two-dimensional governing equations are solved numerically using a finite difference projection algorithm developed at the LBNL Center for Computational Sciences and Engineering coupled with an immersed boundary method. This method allows us to easily handle the complex irregular domains commonly found in blood vessels. Both idealized arterial geometries as well as geometries extracted from clinical imaging data are considered. For the same physical geometry, we compare the shear stress derived numerically with the thickness of the arterial wall in patient data allowing us to assess whether decreased shear stress weakens the vessel wall. (Received September 22, 2009)

1056-76-1971 **Xiaoming Wang***, Department of Mathematics, Florida State University, Tallahassee, FL 32306. *Approximating long time statistical properties of large chaotic systems.*

It is known that physical laws for many large chaotic dynamical systems arising in fluid dynamics are revealed statistically. We present recent progress as well as existing challenges on how to approximate these long time statistical properties for a few fluid problems. (Received September 22, 2009)

# *78 ▶ Optics, electromagnetic theory*

1056-78-582 **Anjan Biswas*** (biswas.anjan@gmail.com), Department of Mathematical Sciences, Delaware State University, 1200 N DuPont Hwy, Dover, DE 19901-2277. *OPTICAL SOLITON PERTURBATION BY HE'S VARIATIONAL PRINCIPLE.*

In this talk, an exact 1-soliton solution will be given for the nonlinear Schrodinger's equation with Kerr and power law nonlinearity, in presence of perturbation terms. The nonlinear Schrodinger's equation governs the propagation of solitons through an optical fiber. The perturbation terms that will be considered are self-steepening term, nonlinear dispersion and Raman scattering. He's variational principle will be used to carry out this integration. (Received September 13, 2009)

1056-78-708 **Xueru Bai*** (bxr@ieee.org), National Key lab. for radar signal processing, Xidian University, taibai road, No.2, and **Mengdao Xing**, **Feng Zhou** and **Zheng Bao** (zhbao@mail.xidian.edu.cn), National Key lab. for radar signal processing, Xidian University, taibai road, No.2, Xi'an, Shaanxi 710071. *Study on ISAR imaging of steadily moving targets with large observation angles.* Preliminary report.

In traditional ISAR imaging, we need to increase the target observation angle to obtain a finer azimuth resolution. However, this in turn will induce range and Doppler curve in the range and azimuth domain respectively. This paper first analysis the available imaging algorithms such as the range-Doppler (RD), the Keystone algorithm, and PFA (Polar Format Algorithm), and deduce their requirements on the observation angles respectively. Then, the complex-valued back-projection algorithm (CBP) is introduced for image formation of a wider observation angle. Finally, imaging results of simulated and measured data are given to compare the performance of the algorithms introduced in this paper. (Received September 21, 2009)

1056-78-864 **Feng Zhou*** (fzhou@mail.xidian.edu.cn), National key. lab for radar signal processing, Xidian University, Taibai road, No.2., xi'an, Shaanxi 710071, Peoples Rep of China, and **Guangcai Sun**, **Xueru Bai** and **Mengdao Xing**. *A Novel Adaptive Method for SAR Jamming Suppression.* Preliminary report.

Based on the target distribution characteristics of SAR imaging, this paper estimates the covariance matrix of data with jamming according to the statistical characteristics of both the SAR image pixels and the jamming. Then, the two-dimensional sinc function distribution of the ideal SAR pixel is utilized as the target steering vector, based on which the optimal adaptive filter is obtained. This filter can suppress the random blanketing noise jamming and therefore improve the image contrast and interpretability. This paper also makes detailed analysis on the theoretical basis and the performance of the proposed algorithm, and then proves the validity of the proposed algorithm by imaging results of simulated data. (Received September 18, 2009)

1056-78-1698 **Zachary Marzec*** (biondini@buffalo.edu), Math Dept, SUNY at Buffalo, Buffalo, NY 14260, **Jonathan Schuster**, Math Dept, SUNY at Buffalo, **Lucas Bunt**, Math Dept, Buffalo State College, and **Benjamin Kanouse**, Math Dept, Buffalo State College. *Efficient computation of failure probabilities in optical fiber communication systems.*

Failures in many industrial systems are extremely rare by design and as a result are very difficult to predict. We develop an adaptive variance reduction technique that combines importance sampling and the cross-entropy method. We then implement this method, to accurately model and predict the occurrence of birefringence-induced failures in installed optical fiber communication systems. (Received September 22, 2009)

1056-78-1760 **Michael J Nicholas*** (mnichol@tulane.edu), Mathematics Department, Tulane University, 6823 St. Charles Ave, New Orleans, LA 70118. *A High Accuracy Algorithm for 3D Periodic Electromagnetic Scattering.*

We develop a highly accurate numerical method for scattering of 3D electromagnetic waves by doubly periodic structures. We approximate scattered fields using the Mueller boundary integral formulation of Maxwell's equations. The accuracy is achieved as singularities are isolated through the use of partitions of unity, leaving smooth, periodic integrands that can be evaluated with high accuracy using trapezoid sums. The removed

singularities are resolved through a transformation to polar coordinates. The method relies on the ideas used in the free-space scattering algorithm of Bruno and Kunyansky. (Received September 22, 2009)

# 81 ► Quantum theory

1056-81-766 **Steven A. Bleiler** (bleilers@pdx.edu), Department of Mathematics and Statistics, Portland State University, PO Box 751, Portland, OR 97207-0751, and **Faisal Shah Khan*** (faisal@pdx.edu), Department of Mathematics and Statistics, Portland State University, PO Box 751, Portland, OR 97207-0751. *Proper quantization of multiplexer circuits, history dependent Parrondo games, and certain Markov processes.*

In the context of quantum information theory, "quantization" of various mathematical constructions is said to occur upon the replacement, at various points in the construction, of the classical randomization notion of probability distribution with the higher order randomization notion of quantum superposition and measurement. For this to be done "properly" one requires that there exist a faithful copy of the original construction within the new "quantum" one, just as is done when one wishes to extend a function to a larger domain. How exactly to accomplish this for the multiplexer circuit of logic synthesis, the history dependent Parrondo game, and for certain Markov processes has been an open problem for some time. A common solution is described herein. (Received September 17, 2009)

1056-81-968 **Chaobin Liu*** (cliu@bowiestate.edu), Bowie State University, Department of Mathematcis, 14000 Jericho Park Road, Bowie, MD 20715, and **Nelson Petulante** (npetulante@bowiestate.edu), Bowie State University, Department of Mathematics, 14000 Jericho Park Road, Bowie, MD 20715. *Quantum Walks with Decoherence on the $N$-Cycle.* Preliminary report.

For a discrete time quantum random walk (QRW) on the $N$-cycle, allowing for decoherence on the coin, we derive a number of new results, including an explicit formula for the position probability distribution. For a QRW of this type, we show that the mixing behavior tends, in the long-run, to a uniform distribution, regardless of the initial state of the system and irrespective of the parity of the number of nodes $N$. Our results confirm the observations of previous authors who arrived at similar conclusions through extensive numerical simulations. In particular, we infer that the mixing time $\overline{M(\epsilon)}$ for the time-everaged probability distribution is of order $O(N^2/\epsilon)$. (Received September 19, 2009)

# 83 ► Relativity and gravitational theory

1056-83-7 **Igor Rodnianski*** (irod@math.princeton.edu), Department of Mathematics, Princeton University, Princeton, NJ 08544. *Evolution problem in General Relativity.*

The talk will introduce basic mathematical concepts of General Relativity and review the progress, main challenges and open problems, viewed through the prism of the evolution problem. I will illustrate interaction of Geometry and PDE methods in the context of General Relativity on examples ranging from incompleteness theorems and formation of trapped surfaces to geometric properties of black holes and their stability. (Received September 22, 2009)

1056-83-349 **Chen-Yun Lin*** (cylin@math.columbia.edu), Mathematics Department, Columbia University, RM 408, MC 4406, 2990 Broadway, New York, NY 10027. *On Hamilton's Ricci flow and Bartnik's construction of metrics of prescribed scalar curvature.*

It is known by work of R. Hamilton and B. Chow that the evolution under Ricci flow of an arbitrary initial metric $g_0$ on $S^2$, suitably normalized, exists for all time and converges to the round metric. In this talk, we describe a construction for metrics of prescribed scalar curvature using solutions to the Ricci flow. The problem is converted into a semilinear parabolic equation similar to the quasispherical construction of Bartnik. We obtain existence results for this equation and discuss applications of the metrics. (Received September 01, 2009)

1056-83-633 **Moritz Andreas Reintjes*** (moritz@math.ucdavis.edu), 103 Grande Ave, Davis, CA 95616. *Shock Waves in General Relativity.*

In this talk I am going to give a short glimpse on the theory of shock waves and introduce their relation to General Relativity, that is, shock waves appear in the matter fields of the Einstein Field Equation with a Perfect Fluid source. In addition I will discuss the regularity class of the metric if shocks are present, namely the constraint equation give rise to a metric that is no more smooth than Lipschitz continuous across the shock surface. However, for the Einstein equation to hold in a classical (almost everywhere) sense, we need the metric to be at least differentiable with Lipschitz continuous partial derivatives. For a single shock surface there always exists a coordinate system such that the metric is that regular, however, this construction fails if two shocks intersect. (Received September 15, 2009)

1056-83-694 **Iva Stavrov*** (istavrov@lclark.edu), Department of Mathematical Sciences, Lewis and Clark College, MSC 110, 0615 SW Palatine Hill Road, Portland, OR 97219. *A gluing construction regarding point particles in general relativity.* Preliminary report.

I discuss a gluing construction yielding initial data which are generalizations of Schwartzchild-De Sitter initial data. The data obey point-particle limits in the sense of Gralla-Wald ("A rigorous derivation of gravitational self-force." Classical Quantum Gravity, 2008.) (Received September 16, 2009)

1056-83-884 **Deborah A. Konkowski*** (dak@usna.edu), Department of Mathematics, U. S. Naval Academy, Annapolis, MD 21012, and **Thomas M. Helliwell** (T_Helliwell@HMC.edu), Department of Physics, Harvey Mudd College, Claremont, CA 91711. *Characteristics of a Classical and Quantum Two-Sphere Singularity.*

The two-sphere singularity in the maximal extension of the Florides exact solution is analyzed. The classical structure shows inextendible incomplete null geodesics (complete timelike geodesics) along with curvature invariants that diverge as the two-sphere is approached. The spacetime of this classical timelike scalar curvature singularity is classified as to its Petrov and Segre types. Its energy conditions together with the strength of the singularity are analyzed to determine the physical relevance of the spacetime. Whether the singularity persists in a quantum sense is considered next. A review of the definition of quantum singularity is given in terms of the essential self-adjoitness of the Klein-Gordon operator using Weyl's limit circle/limit point procedure. The singularity is then shown to remain robust and persist under a quantum wave probe. (Received September 18, 2009)

1056-83-921 **Arick Shao*** (aricks@math.princeton.edu). *Breakdown Criteria for Nonvacuum Einstein Equations.*

We generalize a recent "breakdown criterion" result of S. Klainerman and I. Rodnianski to nonvacuum spacetimes. This breakdown result states roughly that an Einstein vacuum spacetime, given as a constant mean curvature foliation, can be extended if the second fundamental form and the derivative of the lapse of the foliation are uniformly bounded. We adapt this theorem and its proof to Einstein-scalar and Einstein-Maxwell spacetimes. In particular, we deal with a multitude of difficulties resulting from nontrivial Ricci curvature and from the coupling between the Einstein and the field equations. Furthermore, the results we prove can be directly extended to Einstein-Klein-Gordon and Einstein-Yang-Mills spacetimes. (Received September 18, 2009)

1056-83-1022 **Alexander Afriat*** (afriat@gmail.com), Departement de Philosophie, Universite de Bretagne Occidentale, 20 rue Duquesne (campus Segalen), 29285 Brest, France. *Weyl and the foundations (1918, 1929) of gauge theory.*

In 1917 Levi-Civita noted that the parallel transport determined by Einstein's covariant derivative was not integrable—while length, far from depending on the path taken, remained unaltered. For Weyl this was unfair: both features deserved the same treatment. He remedied in 1918 with a connection that made congruent transport (of length) just as path-dependent as parallel transport. This 'total' connection restored justice through a length connection it included, an inexact one-form Weyl couldn't help identifying with the electromagnetic four-potential $A$, whose four-curl $F = dA$, being closed (for $dF = d^2A$ vanishes identically), provides Maxwell's two homogeneous equations. Source-free electromagnetism (up to Hodge duality at any rate) thus came out of Weyl's unusual sense of mathematical justice. Unexpected but admirable (and inaccurate) synthesis of a world that was then made of matter and electromagnetism in curved spacetime. The appearance of a further element, the quantum-mechanical wavefunction, would—by adding an 'ontic' inadequacy to the inaccuracy Einstein had already pointed out—call for another synthesis (of wavefunctions and electromagnetism in curved spacetime), which Weyl undertook in 1929. I consider both theories and the transition between them. (Received September 20, 2009)

1056-83-1051 **A Garrett Lisi*** (gar@lisi.org). *E8 Theory.* Preliminary report.

All gravitational and standard model particle fields may be described as parts of a superconnection valued in the Lie algebra of the split real form of E8, with dynamics described by its curvature. The algebra of standard model fields and their embedding in E8 is exhibited explicitly by a matrix representation, and schematically using weight diagrams. The implications for quantum gravity and particle physics are explored, and open questions discussed. (Received September 20, 2009)

1056-83-1198 **Jacques Smulevici*** (j.smulevici@damtp.cam.ac.uk), Max Planck Institut fur Gravitationsphysik, Am Mühlenberg 1, D-14476 Golm, Germany, and **Philippe G. LeFloch**, 4, Place Jussieu, 75252 Paris, France. *Global geometry of $T^2$ symmetric spacetimes with weak regularity.*

We investigate the global geometry of $T^2$-symmetric spacetimes under low regularity assumptions.

More precisely, denoting by $R$ the area of the orbits of symmetry, we establish the existence (and the uniqueness within the class under consideration) of a global foliation by the level sets of $R$ with $R$ taking all values in the interval $(0, \infty)$. Our weak regularity assumptions only require that the first derivatives of $R$ are bounded while the metric coefficients describing the initial geometry of the orbits of symmetry are in the Sobolev space $H^1$ and the remaining coefficients have even lower regularity. (Received September 21, 2009)

1056-83-1296 **Mihai H Tohaneanu*** (mtohanea@math.purdue.edu), 427 S River Rd, Apt # 21, West Lafayette, CA 47906. *Strichartz estimates for Kerr backgrounds.*

We prove Strichartz estimates for solutions to the equation $\Box_K u = f$, where K stands for the d'Alembertian associated to the metric of the Kerr spacetime. The proof uses the machinery developed in joint work with Jeremy Marzuola, Jason Metcalfe and Daniel Tataru that allows us to obtain Strichartz estimates provided that a suitable local energy estimate already exists. (Received September 21, 2009)

1056-83-1577 **Didier A. Solis*** (didier.solis@uady.mx), Periferico Norte, Tablaje 13615, Col. Chuburna de Hidalgo Inn, 97219 Merida, Yucatan, Mexico, and **Luis A. Farfan** (farfanluis15@hotmail.com), Periferico Norte, Tablaje 13615, Col. Chuburna de Hidalgo Inn, Merida, Yucatan 97219. *Local uniqueness of Minkowski space.*

According to the rigidity philosophy, the existence of a length extremizing geodesic in a semi-riemannian manifold is incompatible with certain curvature inequalities, except under very special circumstances. In the context of asymptotically simple spacetimes, it has been shown that the Null Energy Condition (i.e. $Ricc(X, X) \geq 0, \forall X$ null) prevents the occurrence of a null line (i.e. a globally achronal null geodesic) in a vacuum solution of the Einstein equations, except in the case of Minkowski space (when $\Lambda = 0$) or de Sitter space (when $\Lambda > 0$). In this talk we prove the local uniqueness of Minkowski space in the broader context of globally hyperbolic and asymptotically simple spacetimes. More specifically, under mild causal assumptions on the conformal boundary $\mathcal{J}$ we show that any globally hyperbolic and asymptotically simple spacetime having a null line with endpoints in $\mathcal{J}$ and obeying the vacuum Einstein equations must be locally isometric to Minkowski space. (Received September 22, 2009)

1056-83-1767 **Alberto M Teguia*** (alberto@math.duke.edu), 728 glen hollow dr, durham, NC 27705, and **Arlie O. Petters** and **Brian Rider**. *A Mathematical Theory of Stochastic Microlensing.*

Microlensing is the study of the deflection of light by compact objects and is used to probe the substructure of dark matter. In this talk, we shall present an analytical treatment of stochastic microlensing. In particular, we shall show how the distribution of the random compact objects' position and mass affect the distribution of two fundamentals lensing observables: the number of minimum images and the magnification of a light source. This is a work in progress. (Received September 22, 2009)

1056-83-1910 **Qian Wang*** (qwang@math.sunysb.edu). *Control of local null geometry by rough CMC initial data.*

I will provide an $L^\infty$ type estimate for deformation tensor within certain timespan in terms of 0-order Bel-Robinson energy and volume radius of the initial slice in CMC spacetime, which gives us a lower bound of null radius of injectivity in terms of initial $L^2$ curvature and volume radius, and proves that harmonic radius is locally stable in certain timespan depending on the initial $L^2$ curvature. This result does not rely on any assumption on second fundamental form and lapse function. (Received September 22, 2009)

# 85 ► Astronomy and astrophysics

1056-85-1646 **Philip S Naudus*** (pnaudus1@gmu.edu), 4745 Holly Ave., Fairfax, VA 22030. *Computer Model of Gravitational Lensing Systems.*

Gravitational lensing is a phenomenon which occurs when light from a distant galaxy (referred to as a source galaxy) is deflected by a lensing galaxy. Because of the elaborate mass distribution of lensing galaxies, images become highly distorted, which complicates studying these source galaxies. By solving the gravitational lens equation (in reverse), we were able to map the observed image back onto the plane of the source galaxy. However, this method assumes we know the mass distribution of the lensing galaxy, which is actually not the case since as much of 90% of a galaxy's mass can be dark matter. To solve this problem, we varied the parameters of the lensing galaxy until we were able to reproduce the observed images. Although this is a computationally intense process, we have shown that the dark matter distribution can be found relatively quickly by incorporating interaction between a user and the computer (solutions were found within a few minutes in our test cases). For this reason, current work is underway to create an interactive Java applet which will allow non-experts to contribute to the modeling process. This project promises to determine properties of source galaxies in addition to finding the allocation of dark matter in gravitational lensing systems. (Received September 22, 2009)

# 86 ► Geophysics

1056-86-269 **Nicholas Gewecke*** (gewecke@math.utk.edu), Department of Mathematics, University of Tennessee, Knoxville, TN 37996, and **Tim Schulze**. *The Rapid Advance and Slow Retreat of a Mushy Zone.* 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. Later, the growth slows as the solution is largely depleted of the material forming the dendrites. If the diffusion of the solute is ignored, there is a steady state mushy zone, representative of what is observed over typical laboratory time scales, but even a small amount of diffusion dramatically alters the eventual steady state to a planar solid surface in equilibrium with a uniform solution. The longer time scale of this retreating mushy zone may be of interest in geological settings and highlights some mathematical details that may lurk in simulations of castings. Specifically, if one assumes local thermodynamic equilibrium, the equation governing the evolution of the solid fraction is inherently hyperbolic, so the boundary condition to impose, along with the boundary on which to impose it, becomes a subtle issue. (Received August 23, 2009)

1056-86-1128 **Willi Freeden*** (freeden@mathematik.uni-kl.de), Prof. Dr. Willi Freeden, Geomathematics Group, University of Kaiserslautern, P.O. Box 3049, 67653 Kaiserslautern, Germany. *Geomathematics - Role, Aims, and Potential.*

During the last decades, geosciences and geoengineering were influenced by two essential scenarios: on the one hand technological progress has changed completely the observational and measurement techniques, on the other hand there is a growing public concern about the future of our planet, its climate, its environment, and about the expected shortage of natural resources. Both aspects demand the strong need for new and innovative structures, tools and methods, i.e., geomathematics. The present note represents an attempt to describe geomathematics in its role, its aims, and its potential. (Received September 21, 2009)

1056-86-1134 **Christian Gerhards*** (gerhards@mathematik.uni-kl.de), PO Box 3049, Geomathematics Group, 67653 Kaiserslautern, Germany. *Modeling the Geomagnetic Field by Locally Supported Wavelets.* Preliminary report.

In this talk we present a space oriented multiscale approach to the modeling of electromagnetic currents in the earth's ionosphere. The currents are coupled with the magnetic field via the pre-Maxwell equations which can be reduced to simple differential equations for the poloidal and toroidal scalars involving the surface operators $L^*$, $\nabla^*$ and $\Delta^*$. With help of Green's function for the Beltrami operator $\Delta^*$, we can from this construct locally supported scale-dependent kernel functions to express the currents in terms of a series of convolutions with the magnetic field. Magnetic field data, however, is generally given on a sphere of fixed radius, so that only the radial part of the currents can be adequately reconstructed. Some further physical assumptions reduce the calculation of the horizontal currents to the solution of a spherical counterpart to the pre-Maxwell equations. We give a brief overview on how techniques similar to the radial case can be applied to these differential equations and what physical information one might get from this. (Received September 21, 2009)

1056-86-1135 **Isabel Ostermann*** (osterma@mathematik.uni-kl.de), Geomathematics Group, PO Box 3049, 67653 Kaiserslautern, Germany. *Modeling of Geothermal Flow.* Preliminary report.

Geothermal power is sustainable since the heat extraction is small compared to the Earth's heat content. Nevertheless, there are risks like local depletion especially when using deep geothermal reservoirs. Thus, amongst others, methods to predict the heat transport are needed. We develop a three-dimensional model to simulate geothermal flow in a two-phase porous medium representing the geothermal reservoir which is based on the transient advection-diffusion-equation. (Received September 21, 2009)

1056-86-1546 **Frederik J Simons*** (fjsimons@gmail.com), Department of Geosciences, Guyot Hall 321B, Princeton, NJ 08544. *Slepian Functions for Signal Estimation and Spectral Analysis.*

It is well-known that mathematical functions that are timelimited (or spacelimited) cannot be simultaneously bandlimited (in frequency). Yet the finite precision of measurement and computation unavoidably bandlimits our observation and modeling scientific data, and we often only have access to, or are only interested in, a study area that is temporally or spatially bounded. In the geosciences we may be interested in spectrally modeling a time series defined only on a certain interval, or we may want to characterize a specific geographical area observed using an effectively bandlimited measurement device. Analyzing and representing scientific data of this kind will be facilitated in a basis of functions that is "spatiospectrally" concentrated, i.e. "localized" in both domains at the same time. One particular approach to this "concentration" problem was originally proposed for time series by Slepian and coworkers, in the 1960s. We show how this framework leads to practical algorithms and statistically performant methods for the analysis of signals and their power spectra in one and two dimensions, and on the surface of a sphere. We highlight the connections to sparsity by showing that many geophysical processes are sparse in the Slepian basis. (Received September 22, 2009)

# 90 ► Operations research, mathematical programming

1056-90-33 **Brenda Dietrich***, IBM, Watson Research Center, Yorktown Heights, NY. *Optimization Inside: The use of mathematical methods in business processes.*

In this talk I will address some emerging opportunities for the application of optimization in business processes. These opportunities are enabled by years of advancement in computing performance, by automation and standardization of business processes, by the establishment of robust software libraries, and by the compilation of vast data sets. There are also emerging challenges presented by new hardware architectures and the need for near real time decision making. Examples will be drawn from a wide range of IBM projects. (Received July 06, 2009)

1056-90-176 **Anton Abdulbasah Kamil*** (anton@usm.my), School of Distance Education, Universiti Sains Malaysia, 11800 Penang, Penang, Malaysia, and **Md Azizul Baten**, School of Distance Education, Universiti Sains Malaysia, 11800 Penang, Penang, Malaysia. *Production Inventory Planning in a Stochastic Manufacturing System with Discounted Cost.*

The paper is concerned with the production inventory planning in a stochastic manufacturing system with minimizing the expected discounted production cost control problem. We develop the optimal production inventory control problem associated with the reduced (one-dimensional) Hamilton-Jacobi Bellman equation. The analysis proceeds with a study of the developed production inventory control problem with a discounted cost. We establish the uniqueness solution of this Hamilton-Jacobi-Bellman equation associated with this problem. (Received August 11, 2009)

1056-90-597 **Sundeep Samson*** (sundees@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634, and **James A Reneke** (reneke@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634. *Balancing a dissipative linear SDE with uncertain parameters.*

Consider a design problem for a system modeled by a dissipative linear stochastic differential equation with uncertain parameters. Uncertainty is approached in F. M. Knight's sense, i.e., uncertain means knowable but unknown. Hence uncertainties are handled without assuming a distribution. The design objective is minimizing over all uncertainty values a functional, system imbalance depending on system design parameters, defined on the sample paths of the system response. The design problem is formulated as a stochastic multi-criteria optimization problem over a function space. A design preference is given in terms of value at risk dependent on uncertainty values. Resolution of the stochastic multi-criteria optimization problem produces a preferred design that balances the system. (Received September 14, 2009)

1056-90-608 **Abebaw Tadesse*** (atadesse@lunet.edu), P.O.Box 126, Langston, Oklahoma, Langston, OK 73050, and **Franklin Fondjo Fotou**, OK. *Applications of Ensemble based Simulated Annealing to Intensity Modulated Radiation Therapy Planning(IMRTP).* Preliminary report.

In this talk, We will prsent preliminary results on the testings on the applications of Ensemble based simulated annealing algorithms on 2D- Dimensional Intesity Modulated Therapy Planning(2D-IMRT) on two artificial 2D geometries.In the end, current progress and future directions on 3D-IMRT and parallel Simulated annealing will also be discussed. (Received September 14, 2009)

1056-90-1078 **Rick Chartrand*** (rickc@lanl.gov), Theoretical Division, MS B284, Los Alamos, NM 87545. *Nonconvex compressive sensing: getting the most from very little information.*

In this talk we'll look at the exciting, recent results showing that most images and other signals can be reconstructed from many fewer data than previously thought possible, using simple, efficient algorithms. A consequence has been the explosive growth of the new field known as compressive sensing, so called because the results show how a small number of measurements of a signal can be regarded as tantamount to a compression of that signal. The many potential applications include reducing exposure time in medical imaging, inferring the state of infrastructure networks from measurements taken at a limited number of nodes, and reducing the data storage/transmission/processing burden on deployed sensor systems.

We'll see how substituting a nonconvex objective function (such as the $\ell^p$ quasinorm, with $p < 1$) into the convex optimization problem typically used in this field has the effect of reducing still further the number of measurements needed to reconstruct a signal. A very surprising result is that simple algorithms, designed only for finding one of the many local minima of the optimization problem, typically find the global minimum. In this talk we'll look at examples, algorithms, and theory. (Received September 20, 2009)

1056-90-1181 **Pierre R. Merel*** (merel@primal.ucdavis.edu), Agricultural and Resource Economics, UC Davis, 1 Shields Avenue, Davis, CA 95616, and **Santiago Bucaram**, Agricultural and Resource Economics, UC Davis. *Exact Calibration of Programming Models of Agricultural Supply against Exogenous Sets of Supply Elasticities.*

A methodology is developed to exactly calibrate programming models of agricultural supply against exogenous sets of supply elasticities. Although earlier literature has recognized the need to incorporate prior information on elasticities to such models, calibration procedures are not widely available. Previous studies have used "myopic" calibration ignoring the change in the shadow price of constrained resources induced by price changes, leading to erroneous implied elasticities. An exact calibration procedure has been proposed by Heckelei (2002) for models with Leontief-type production functions and quadratic adjustment cost. We show that this procedure does not allow calibration against any arbitrary set of supply elasticities, however. We derive a test that allows the analyst to determine *ex ante* whether the calibration problem has a solution, and prove that this solution, if it exists, is unique. We propose a general calibration procedure for models with input allocation, and apply it to the CES-quadratic model of Howitt (1995). Our procedure yields closed-form solutions for the elasticity equations and thus permits exact calibration without the use of duplicate sets of first-order conditions, as initially proposed by Heckelei (2002). (Received September 21, 2009)

1056-90-1503 **Emmanuel Candes*** (candes@stanford.edu), Department of Mathematics, Stanford University, Stanford, CA 94305, and **Terence Tao** (tao@math.ucla.edu), Department of Mathematics, University of California, Los Angeles, Los Angeles, CA 90095-1555. *The Power of Convex Relaxation: Near-optimal Matrix Completion.*

This talk considers the problem of recovering a data matrix from a sampling of its entries (this is an instance of the famous Netflix problem). Suppose we observe a few matrix entries selected uniformly at random. Can we complete the matrix and recover the entries we have not seen? Surprisingly, we show that we can recover low-rank matrices exactly from very few sampled entries; that is, from a minimally sampled set of entries. Further, perfect recovery is possible by solving a convex optimization program—a convenient SDP. Our methods are optimal and succeed as soon as recovery is possible by any method whatsoever, no matter how intractable; this result hinges on powerful techniques in probability theory, and is robust vis a vis noise. (Received September 22, 2009)

1056-90-1745 **Ali Kemal Unver*** (aunver@asu.edu), 3000 High View Dr., Apt.#1522, Henderson, NV 89014. *Extraction of Transport Coefficients in Stochastic Production Systems.*

Continuum models of re-entrant production systems are developed that treat the flow of products in analogy to traffic flow. Specifically, the dynamics of material flow through a re - entrant factory via a parabolic conservation law is modeled describing the product density and flux in the factory. The basic idea underlying the approach is to obtain transport coefficients for fluid dynamic models in a multi-scale setting simultaneously from Monte Carlo simulations and actual observations of the physical system, i.e. the factory. Since partial differential equation (pde) - conservation laws are successfully used for modeling the dynamical behavior of product flow in manufacturing systems, a re - entrant manufacturing system is modeled using a diffusive pde. The specifics of the production process enter into the velocity and diffusion coefficients of the conservation law. (Received September 22, 2009)

1056-90-1776 **L. A. Melara*** (lamelara@ship.edu), Department of Mathematics, Shippensburg University, 1871 Old Main Drive, Shippensburg, PA 17257-1804, and **A. J. Kearsley** (ajk@nist.gov), NIST, Gaithersburg, MD 20899. *An Estimate of The Radius of an Attraction Ball for TV-Minimization Problems in Image Denoising.*

Homotopy methods can often be used to make mathematical programming problems easier to solve. One source of notoriously difficult problems is total variation image denoising problems. In this talk, the speaker will present a method using a regularization parameter as a homotopy parameter to numerically approximate solutions to TV-equality constrained minimization problems. We present an estimate on the radius of the Kantorovich ball centered at the initial iterate of Newton's method. Furthermore, we show an estimate on the radius of an attraction ball centered at the solution of the optimization problem. The talk will summarize numerical results and convergence results. (Received September 22, 2009)

1056-90-2041 **Ahlam E Tannouri*** (ahlam.tannouri@morgan.edu), Baltimore, MD 21251, and **Sam F Tannouri** (sam.tannouri@morgan.edu), Baltimore, MD 21251. *Modeling Network Traffic as a Filtered Semi-Markov-Process.* Preliminary report.

The Markov renewal process known as the semi-Markov process (SMP) is an important generalization of the Markov chain. This process is critical in analyzing and studying queuing Problems. Network traffic congestion causes serious problems affecting major websites at critical times. The extent of disturbance on the major flow of information in a network is modeled as a filtered SMP. Clustering, variability and spacing are considered. The model can be used to establish an intervention plan at random times in transient and asymptotic cases. (Received September 22, 2009)

1056-90-2067 **Kourosh Modarresi*** (kouroshm@stanfordalumni.org), P O Box 19544, Stanford, CA 94309. *Mathematical Analysis of Smart Grids Using Randomized Algorithms.*

Mathematical Analysis of Smart Grids Using Randomized Algorithms Smart grids address the issue of stochastic electricity demand and production in addition to other issues such as security and system data integration. Though the more conventional demand has always been variable, the increasing numbers of plug-in-hybrid electric vehicles (PHEVs) and plug-in electric vehicles (PEVs) in the coming years has made the management of the stochastic demand a critical issue for power grids and energy sustainability. The increasing rules of solar and wind energy sources are the main source of variability for electricity production. The solution and analysis of smart grids problem using deterministic algorithms is computationally very expensive and unrealistic, especially due to the high dimension of the problem. In this work we show how effective alternative algorithmic schemes, using randomized algorithms, could be used for the simulation and optimization approaches of smart grid problems. (Received September 23, 2009)

1056-90-2129 **Ye (Alice) Tian*** (ytian@math.wsu.edu), 1445NE, North Fairway, Dr L45, pullman, WA 99163. *Optimization in Developing Prediction Scoring Function for Mutagenesis Solubility.*

Mutagenesis is the process of replacing one or more amino acids in a protein by alternative amino acids to generate a mutant protein. Computational techniques can be invaluable to predicting the changes to the properties without having to actually make the mutations.

We use concepts from computational geometry to develop a weighted scoring function to predict the change of protein solubility due to mutations. The scoring function captures both protein sequence and structure information. We present two Linear Programming (LP) models to train the scoring function. The first one is a two-phase model that tries to distinguish boundary between increased solubility and decreased solubility instances. The second model is trying to minimize the deviations of all instances from hitting the target values. The second model also shows robustness for different target values. Utilizing Leave-One-Out Cross Validation method for training and prediction, a prediction accuracy 94.5% is achieved.

Compared to standard learning methods such as Support Vector Machines (SVM), the LP method offers more flexibility, and is less sensitive to outliers as the objective function is linear. (Received September 23, 2009)

1056-90-2136 **Pablo A Parrilo*** (parrilo@mit.edu), Massachusetts Institute of Technology, 77 Massachusetts Ave, RM 32D-726, Cambridge, MA 02139. *The convex algebraic geometry of rank minimization.*

Optimization problems involving ranks of matrices are of great importance in applied mathematics and engineering. They provide a rich and fruitful interaction between algebraic-geometric concepts and convex optimization, with strong connections and synergies with popular techniques for sparsity minimization like compressed sensing. In this talk we will describe the key results in this exciting research area, highlighting the geometric and conceptual aspects as well as surveying recent work, applications and algorithms. (Received September 23, 2009)

# 91 ► Game theory, economics, social and behavioral sciences

1056-91-84 **Sarah Berube**, 255 Grapevine Road, Wenham, MA 01984, and **Karl-Dieter Crisman*** (karl.crisman@gordon.edu). *Manipulating Profiles in Nonparametric Statistics: Stacking and Switching.* Preliminary report.

A number of well-known results of D. Haunsperger connect voting theory - including the paradoxes involved - with certain non-parametric tests in statistics. Recently, A. Bargagliotti and D. Saari have recast and extended many of these results in terms of geometric/algebraic symmetry decompositions of the space of voter profiles arising from statistical data sets, especially in the three sample case.

In this talk, we first characterize the effects on outcomes of a manipulation we call 'stacking' of the profile space; an immediate result of this characterization is that one can create profiles arbitrarily close to being purely Basic. By applying another manipulation called 'switching', we can give a useful first characterization of pure Basic profiles as well. Finally, these are shown to actually exist via computer search (disproving a conjecture of Bargagliotti and Saari). (Received July 23, 2009)

1056-91-138 **Angela King*** (angie.king@mail.mcgill.ca), 3445 Stanley Street, Apartment 4, Montreal, Quebec H3A 1S2, Canada, **Adam Biesenbach** (abiesenb@gmail.com), P.O. Box 274431, Rochester, NY 14627, and **Kuni Natsuki** (knatsuki92@gmail.com), 279 Dondero Way, San Jose, CA 95119. *Analysis of the Repackaging of Risk in the Sub-Prime Mortgage Crisis.* Preliminary report.

Our research examines the copula method used to rate collateralized debt obligations (CDOs) in the mortgage market. The copula method links the marginal probability of default of individual mortgages to a joint distribution, and takes into account correlation, which plays an important role in the financial industry. The most popular model used in industry is the one factor Gaussian copula. Through Monte Carlo simulation, we tested this and several other copula models against the two primary criteria used to rate CDOs: probability of loss, used by Standard and Poor's, and expected loss, used by Moody's. We extended the current research in two ways. First, we designed efficient computational programs to reach statistical conclusions by observing confidence intervals: the probability of loss criterion is a more conservative method. Secondly, we conclude that the different copulas used greatly affect the modeled risk, which should be considered seriously by credit rating agencies. (Received July 31, 2009)

1056-91-251 **Andrew Clark*** (andrew.clark@thomsonreuters.com), 707 17th Street, Denver, CO 80204. *Continuous Time Model of Bifurcations and Related Phenomena in Agent-Based Models.*

In this brief paper the author will show how a common description of stock prices – the Ornstein-Uhlenbeck process – can be modified so it can explain the bifurcations and related phenomena seen in stock prices when they are modeled by determiniistic agent-based modeling.

In particular this paper will use the infinitesimal generators (IG) of diffusion processes to show that at the onset of the initial bifurcation, the standard Ornstein-Uhlenbeck pdf changes and other pdfs come to the fore due to a noise-induced transition. Related phenomena are explained as being either additive or multiplicative noise processes that arise due to the mix of risk-aversion parameters and/or window length.

The paper will also recommend ways its conjecture can be proven (or disproven) empirically. (Received August 19, 2009)

1056-91-620 **Anna Popova*** (apopova2@uiuc.edu), 603 E Daniel str., Champaign, IL 61820, and **Michel Regenwetter** (regenwet@uiuc.edu), 603 E Daniel str., Champaign, IL 61820. *Concensus among Concensus Methods.* Preliminary report.

Social choice theory in Economics and Political Science has highlighted that competing notions of rational social choice are irreconcilable, because of impossibility theorems and computer simulations. Do concensus methods disagree so much in reality? We report on a behavioral social choice comparison of Condorcet, Borda, Plurality, Negative Plurality, STV, Coombs, and Plurality Runoff one, using several data sets from American Psychological Association presidential elections. The empirical findings contradict theoretical expectations. Behavioral research in social choice may reveal many future surprises. Explaining the empirical agreement

among social choice outcomes is an open problem (Regenwetter, 2009, Perspectives on Psychological Science).
(Received September 14, 2009)

1056-91-710 **D. Marc Kilgour*** (mkilgour@wlu.ca), Dept of Mathematics, Wilfrid Laurier University, 75 University Avenue West, Waterloo, ON N2L 3C5, Canada. *Approval Balloting for Multi-Winner Elections.*

Approval balloting seems a natural approach to multi-winner elections, in that both the ballot and the election result are subsets of the candidates. In this survey of procedures for converting a set of approval ballots to a winning subset, the class of *admissible*, or potentially winning, subsets is considered to be a parameter of the election. Most procedures for multi-winner elections are *scoring* procedures—an admissible subset with the highest score wins—but some are better understood as *threshold* procedures, which select an admissible subset that meets a standard of representativeness as often as possible, or *centralization* procedures, which find an admissible subset that is "central" in the distribution of ballots. The main purpose of this paper is to collect and classify the procedures. Some comparative properties are mentioned, as are the implications of common forms of admissibility for choice of procedure. (Received September 16, 2009)

1056-91-714 **Michael A Jones*** (maj@ams.org), Mathematical Reviews, 416 Fourth Street, Ann Arbor, MI 48103, and **Jennifer M. Wilson** (wilsonj@newschool.edu), The Eugene Lang College, The New School for Liberal Arts, Department of Mathematics, New York, NY 10011. *The Evaluation and Comparison of Thresholds for Divisor Methods.*

Of crucial interest in any apportionment method are the thresholds or lower and upper bounds for the percentage of population that are necessary and sufficient for a state to receive a particular number of seats. Palomares and Ramirez equated thresholds with the solutions of optimization problems. Using an intuitive concavity lemma, we solve the optimization problems for divisor methods of apportionment with concave up or concave rounding functions. This allows us to prove explicit formulas for threshold values of certain divisor methods—thereby increasing the class of divisor methods for which thresholds may be calculated. We use the formulas to analyze the behavior of these thresholds, and compute and compare threshold values for Hill-Huntington's method (used to apportion the U.S. House of Representatives), methods based on the identric and logarithmic means, and other divisor methods. (Received September 16, 2009)

1056-91-732 **Jennifer M Wilson*** (wilsonj@newschool.edu), 65 W. 11th St., New York, NY 10011, and **Michael A Jones** (maj@ams.org). *Minimal Requirements for Representation in the Democratic Primary.*

The Democratic Party uses Hamilton's method of apportionment to assign delegates to presidential candidates based on the candidates' level of support in the primary. However party rules state that candidates receiving less than 15% of the vote are not awarded any delegates. In this talk, we look at the consequences of such a cut-off for Hamilton's method and several other apportionment methods. For each method, we find the threshold of inclusion (the level of support necessary to possibly receive a delegate), and the threshold of exclusion (the level of support necessary to assuredly receive a delegate). We compare these values and determine the relationship between the thresholds and the Democratic Party cutoff of 15%. (Received September 16, 2009)

1056-91-752 **Steven J. Brams*** (steven.brams@nyu.edu), Dept. of Politics, New York University, 19 West 4th St., 2nd Fl., New York, NY 10012, and **D. Marc Kilgour** (mkilgour@wlu.ca), Dept. of Mathematics, Wilfrid Laurier University, Waterloo, Ontario N2L 3C5, Canada. *Satisfaction Approval Voting.*

We propose a new voting system, satisfaction approval voting (SAV), for multiwinner elections, in which voters can approve of as many candidates or as many parties as they like. However, the winners are not those who receive the most votes, as under approval voting (AV), but those candidates or parties that maximize the sum of the satisfaction scores of all voters, where a voter's satisfaction score is the fraction of his or her approved candidates who are elected. If individuals are the candidates, SAV may give a different outcome from AV–in fact, SAV and AV outcomes may be disjoint–but SAV generally chooses candidates representing more diverse interests than does AV (this is demonstrated empirically in the case of a recent election of the Game Theory Society). On the minus side, it may encourage more bullet voting than does AV. In party-list systems, SAV apportions seats to parties according to the Jefferson/d'Hondt method with a quota constraint, which favors large parties and gives an incentive to smaller parties to coordinate their policies and forge alliances, even before an election, that reflect their supporters' coalitional preferences. (Received September 16, 2009)

1056-91-780 **Anna E Bargagliotti*** (abargag@yahoo.com), 709 Harbor Edge Circle #301, Memphis, TN 38103, and **Michael Orrison**. *Statistical Inconsistencies of Ranked Data.*

Several nonparametric tests exist to test for difference among alternatives when using ranked data. Testing for difference among alternatives amounts to testing for uniformity over the set of possible permutations of the alternatives. Well-known tests of uniformity such as the Friedman test or the Anderson test, are based on the impact of the usual limiting theorems (e.g., Central Limit Theorem) and the creation of different summary statistics (e.g., mean ranks, marginals, pairwise votes). As with voting theory election procedures, similar inconsistencies can occur using these statistical tests– different statistical tests may yield different outcomes when applied to the same data. Using parallel ideas developed in voting theory, in this talk we show how to use a natural decomposition of the underlying ranking space to explain why nonparametric test results can differ and how their different are related. (Received September 17, 2009)

1056-91-909 **Tamas Forgacs*** (tforgacs@csufresno.edu), Department of Mathematics, 5245 North Backer Avenue, M/S PB 108, Fresno, CA 93740-8001, and **Attila Cseh** and **Adnan Sabuwala**. *Addiction and Treatment in a rational framework - can lowering health care costs have adverse effects?* Preliminary report.

In this paper we construct a formal model to analyze how a change in the price of health care services affects the consumption of addictive goods. We build upon the seminal paper of Becker and Murphy (1988) on rational addiction in that we investigate the optimal paths of consuming an addictive good $c$ (say drugs or alcohol) and treatment $h$ for the addiction from the point of view of a utility maximizing agent. An added feature of our model is that we allow past consumption of $c$ to have an effect the present consumption of $h$ and vica-versa. We find that in certain cases our model can predict an increase in the consumption of an addictive good as a consequence of a decrease in the price of health care services. For example if the treatment of an addiction is itself addictive, then given symmetric preferences and price structure, a decrease in the price of the treatment triggers an increase in the use of the addictive good. We obtain a similar result with less restrictive assumptions on the agent's preferences and on the price structure. Though one can obtain a general solution to our model, the qualitative analysis of the general solution is less tractable. Thus we restrict our analysis to cases of simplified preference structures. (Received September 18, 2009)

1056-91-1065 **Michel De Lara*** (delara@cermics.enpc.fr), CERMICS, Universite Paris-Est, 6 et 8 avenue Blaise Pascal, 77455 Marne la Vallee, France. *Preferences Yielding the Precautionary Effect.*

We study ranking of optimal initial decisions in two-stages decision problems with and without information arrival. Consider an agent taking two successive decisions to maximize his expected utility under uncertainty. After his first decision, a signal is revealed that provides information about the state of nature. The observation of the signal allows the decision-maker to revise his prior and the second decision is taken accordingly. Assuming that the first decision is a scalar representing consumption, the *precautionary effect* holds when initial consumption is less in the prospect of future information than without (no signal). Epstein (1980) has provided the most operative tool to exhibit the precautionary effect. Epstein's Theorem holds true when the difference of two convex functions is either convex or concave, which is not a straightforward property, and which is difficult to connect to the primitives of the economic model. Our main contribution consists in giving a geometric characterization of when the difference of two convex functions is convex, then in relating this to the primitive utility model. With this tool, we are able to study and unite a large body of the literature on the precautionary effect. (Received September 20, 2009)

1056-91-1129 **Yuanying Guan***, FSU Mathematics, 208 Love Building, 1017 Academic Way, Tallahassee, FL 32306. . Preliminary report.

Lucas pricing model has been a very popular model in macroeconomics during the past decade. However, it has certain unrealistic assumptions such as homogeneous agents assumption. In our research, we are trying to relax this assumption and incorporate learning schemes for agents to simulate pricing evolvement and agents' holdings change in the stock market. With heterogeneous agents and adaptive learning rules , we are able to set up dynamical systems for price change and share holding variation.

Some interesting numerical results show that, when agents have certain risk aversions, the pricing function of stock evolves in a chaotic way. Compared to a general convergent pricing kernel, this chaotic behavior could possibly give us more information about real market. Currently, we are looking for effective approaches to analyze behavior of pricing function in different cases, especially those chaotic cases. Nonlinear time series analysis has given us a general sense about structure of chaos. The topology structure of dynamics need to be explored and relevant market information would be explained.

(Received September 21, 2009)

1056-91-1196 **Larry S Karp*** (karp@are.berkeley.edu), 207 Gianni Hall, Berkeley, CA 94720, and **Yacov Tsur**. *Time perspective and climate change policy.*

The tendency to foreshorten time units as we peer further into the future provides an explanation for hyperbolic discounting at an intergenerational time scale. We study implications of hyperbolic discounting for climate change policy, when the probability of a climate-induced catastrophe depends on the stock of greenhouse gasses. We provide a positive analysis by characterizing the set of Markov perfect equilibria (MPE) of the intergenerational game amongst a succession of policymakers. Each policymaker reflects her generation's preferences, including its hyperbolic discounting. For a binary action game, we compare the MPE set to a "restricted commitment" benchmark. We compare the associated "constant equivalent discount rates" and the willingness to pay to control climate change with assumptions and recommendations in the Stern Review on Climate Change. (Received September 21, 2009)

1056-91-1202 **Josep Freixas*** (josep.freixas@upc.edu), Av. Bases de Manresa 61-73, 08242 Manresa (Barcelona), Spain, 08242 Manresa, Barcelona, Spain, **Xavier Molinero** (molinero@lsi.upc.edu), Av. Bases de Manresa 61-73, 08242 Manresa (Barcelona), Spain, 08242 Manresa, Barcelona, Spain, **Montserrat Pons** (montserrat.pons@upc.edu), Av. Bases de Manresa 61-73, 08242 Manresa, Spain, 08242 Manresa, Barcelona, Spain, and **Dorota Marciniak** (dorofia@gmail.com), Institute of Mathematics of the Polish, Academy of Sciences and National Institute, of Telecommunications, Warsaw, Poland. *On the ordinal equivalence of power indices.*

Different reasonable power indices provide different orderings of importance for voters, so that the evaluation of (a priori) power in (binary) voting systems is quite arbitrary since the rankings depend on the particular power index chosen. One is left with the hope that such discrepancies occur because the voting system at hand is rare enough. To better understand what happens, we analyze the ordinal equivalence of families of power indices.

Power indices based on symmetric probabilistic values (or semivalues) with positive coefficients (regular semivalues), as the Banzhaf index or the Shapley-Shubik index, share the same rankings of voters within the class of weakly complete games. Weakly complete games contain weighted and complete games and, therefore, the most common real voting systems. This partially solves the problem because power indices are mostly applied to non-complicated voting systems derived from real problems which always are weakly complete.

The Johnston index also shows a good behavior since it is ordinally equivalent to Banzhaf and Shapley-Shubik indices in a sufficiently large class of games containing complete games. Necessary and sufficient conditions are given to determine such a class. (Received September 21, 2009)

1056-91-1274 **Michael R Springborn*** (mspringborn@ucdavis.edu), 2104 Wickson Hall, One Shields Blvd, Davis, CA 95616, and **Robert Lieli**. *Closing the gap between risk estimation and decision-making: efficient management of trade-related invasive species risk.* Preliminary report.

In this paper we assess multiple alternatives for designing a screening system to make decisions to allow or exclude novel imported goods. The statistical decision problem is to use available information on previous imports to parameterize a predictive model of the key unknown—a proposal's latent status as damaging or benign. We develop the first side-by-side comparison of two classical approaches—maximum likelihood and Bayesian—against a third, recently developed "maximum utility" (MU) estimation methodology. We demonstrate the implications of the expected payoffs (benefits and potential damages) of a risky import for the risk estimation problem. The MU approach utilizes the insight that a global fit of the statistical model is less important than the localized problem of identifying the best switching point from one discrete decision to another, e.g. from rejection to acceptance of a proposed import. We develop an empirical application using Australian data based on the problem of choosing to reject or accept novel plant imports given that the primary unknown is whether or not the proposal will become invasive. We demonstrate when the MU method is likely to offer significant incremental gains and estimate this annual value to be \$32-\$66 million (AU\$). (Received September 21, 2009)

1056-91-1533 **Thomas C. Ratliff*** (tratliff@wheatoncollege.edu), Department of Mathematics & Computer Science, Wheaton College, 26 E. Main St, Norton, MA 02048, and **Donald G. Saari**. *Selecting Diverse Committees.*

Selecting a committee can become complex when the voters have preferences for the entire composition of the committee which cannot be reduced to candidate-by-candidate preferences. For example, the gender or ethnic diversity of the committee may be extremely important to the electorate, and different voters may place priority on different criteria. If the voters express their preferences on a candidate-by-candidate basis, it is not only possible to select a homogeneous committee that is unacceptable to every voter, but this has happened in practice. One option is to require the voters to provide a complete ranking of all possible committees and apply a standard voting procedure to this profile, but this is often infeasible since the number of possible committees can be extremely large. We first consider selecting a committee of size three where there are two candidates for each of the three positions on the committee and the electorate agree on a common diversity criterion. We describe a simple voting method that will never select a universally unacceptable committee in this case. We provide a geometric framework to explore the implications of extending to more candidates and to multiple diversity criteria among the voters. (Received September 22, 2009)

1056-91-1642 **John Cloutier**, Department of Mathematics, University of California at Santa Barbara, Santa Barbara, CA 93106, **Kathryn L. Nyman*** (knyman@willamette.edu), Department of Mathematics, Willamette University, Salem, OR 97301, and **Francis Edward Su**, Department of Mathematics, Harvey Mudd College, Claremont, CA 91711. *Two player envy-free multi-cake division using a polytopal Sperner's lemma.*

We introduce a generalized cake-cutting problem in which we seek to divide multiple cakes so that two players may get their most-preferred piece selections: a choice of one piece from each cake, allowing for the possibility of linked preferences over the cakes. For two players, we show that disjoint envy-free piece selections may not exist for two cakes cut into two pieces each, and they may not exist for three cakes cut into three pieces each. However, there do exist such divisions for two cakes cut into three pieces each, and for three cakes cut into four pieces each. The resulting allocations of pieces to players are Pareto-optimal with respect to the division. We use a generalization of Sperner's lemma on the polytope of divisions to locate solutions to our generalized cake-cutting problem. (Received September 22, 2009)

1056-91-1704 **Nicholas De Meglio** and **Rebecca Hager*** (rshager@buffalo.edu), 244 Mathematics Bldg, Mathematics Department, Buffalo, NY 14260, and **Jorge Wu Mok**, **Matthew Westley** and **Surajit Sen**. *A study of a two species battle between an intelligent army and insurgent defenders.*

We develop a simple model of a battle using a two-species cellular automaton. This model quickly leads to surprising complexity and rich behavior, especially in battles between two well-matched sides. In this paper, we examine global terrain effects upon the outcome of a battle - cities, narrow pathways, and other constraints. We further investigate the consequences to these "symmetric" battles when one side is highly intelligent. Modifying strategy according to the current state of the battlefield ("adaptive strategy") is found to be extremely effective in winning battles. (Received September 22, 2009)

1056-91-1858 **Robert Z Norman*** (rzn@dartmouth.edu), Mathematics Department, 6188 Kemeny, Dartmouth College, Hanover, NH 03755-3551. *Frequency of violations of monotonicity.*

By Arrow's monotonicity axiom for ranked voting systems, if a profile $P$ (a set of rankings of candidates by voters) produces candidate $y$ as the winner, then $y$ should still be the winner for any profile $P'$ obtained from $P$ as a result of moving $y$ up in some rankings. If, on the contrary, there is such a profile $P'$' for which $y$ is not the winner, then we say that both $P$ and $P'$ violate monotonicity. An election violates monotonicity if its profile does. Single Transferrable Vote (STV), among other systems, doesn't satisfy monotonicity. For a class of contested three-candidate elections using STV, we find that 15% to 25% of their profiles violate monotonicity. More than half of these have majority cyclic triples, which are rare in real elections. Does that mean few contested elections violate monotonicty? Joseph Ornstein's examination of simulations for such contested elections finds similar frequencies of violations of monotonicity, but these elections rarely have majority cyclic triples. Violations of monotonicity are related to the no-show paradox. We conclude by showing the relationships among violations of monotonicity, majority cyclic triples, and the no-show paradox in profiles for contested elections. (Received September 22, 2009)

1056-91-1917 **Klay Kruczek*** (kruczekk@wou.edu), Mathematics Department, 345 N. Monmouth Avenue, Monmouth, OR 97361, and **Eric Sundberg**. *Potential-Based Strategies for Breaker for Maker-Breaker Tic-Tac-Toe on the Integer Lattice with Numerous Directions.*

We consider a Tic-Tac-Toe game played on the $d$-dimensional integer lattice. The game that we investigate is a Maker-Breaker version of Tic-Tac-Toe. In a Maker-Breaker game, the first player, Maker, only tries to occupy a winning line and the second player, Breaker, only tries to stop Maker from occupying a winning line. We consider the bounded number of directions game, in which we designate a finite set of direction-vectors $\mathcal{S} \subset \mathbb{Z}^d$

which determines the set of winning lines. We show, by using the Erdős–Selfridge theorem and a modification of a theorem by Beck about games played on almost-disjoint hypgergraphs, that for the special case when the coordinates of each direction-vector are bounded, i.e., when $\mathcal{S} \subset \{\vec{v} : \|\vec{v}\|_\infty \le k\}$, Breaker can win this game if the length of each winning line is on the order of $d^2 \lg(dk)$ and $d^2 \lg(k)$, respectively. (Received September 22, 2009)

1056-91-1923 **Kym C Louie*** (kym.louie@gmail.com), 340 E. Foothill Blvd., Claremont, CA 91711, and **Mike Egesdal**, **Jeremy Neuman** and **Chris Fathauer**. *Statistical Modeling of Gang Violence in Los Angeles.*

Gang violence has plagued the Los Angeles policing district of Hollenbeck for over half a century. With sophisticated models, police may better understand and predict the region's frequent gang crimes. The purpose of this research is to model Hollenbeck's gang rivalries. A self-exciting point process called a Hawkes process is used to model rivalries over time. While this is shown to fit the data well, an agent-based model is presented which is able to accurately simulate gang crimes not only temporally but also spatially. Random graphs generated by the agent model are compared to existing models that incorporate geography into random graphs. (Received September 22, 2009)

1056-91-1983 **Jin-Chuan Duan**, NUS Risk Management Institute, 21 Heng Mui Keng Terrace, Level 4, Singapore, 119613, Singapore, **Anirban Dutta*** (anirban.dutta@wmich.edu), Department of Mathematics, Western Michigan University, 1903 W. Michigan Avenue, Kalamazoo, MI 49008-5248, and **Qiji J. Zhu**, Department of Mathematics, Western Michigan University, 1903 W. Michigan Avenue, Kalamazoo, MI 49008-5248. *Option pricing for biomedical firms with predictable price jumps.* Preliminary report.

We focus on biomedical firms with small market capitalization. Usually these companies have one or two products in the pipeline. The survival or demise of these companies depend on the success of these products. FDA decisions on these drugs or technologies are crucial in these matters. Several months before FDA decisions are announced the news of the pending decisions come out. It is imperative that stock price will jump after the decision or the trial results comes out. Premium for options maturing after the pending decision jumps at this time. A smaller price jump is observed at this point.

We modeled the price as a combination of jump and mixture diffusion processes. After the news of a pending decision is out, we modeled the price process as a mixture of a pessimistic and an optimistic process. After the actual decision the price process is modeled to choose one of the mixture components. We compute pricing formulas for such processes and show that there is a theoretical jump in option prices after the news comes out. We also show evidence in the market data for such mixture processes and how the processes drift away from each other over time. (Received September 22, 2009)

1056-91-2017 **Duane Cooper*** (dcooper@morehouse.edu), Department of Mathematics, Morehouse College, 830 Westview Dr. SW, Atlanta, GA 30314. *Analysis of Cumulative Voting's Potential to Yield Fair Representation.*

For representative bodies, the election method of cumulative voting replaces the democratic principle of "one person, one vote" with "one person, $n$ votes", where $n$ is the number of representatives to be elected in the jurisdiction. We describe results on the potential of cumulative voting to yield fair representation to minority populations by comparison to apportionment methods. We extend this consideration beyond measures of fairness to population subgroups to consideration of fairness to individual voters via spatial modeling. (Received September 22, 2009)

1056-91-2025 **Craig A. Tovey*** (cat@gatech.edu), School of ISyE, Georgia Tech, Atlanta, GA 30332-0205, and **Dylan Shepardson**. *A Smallest Tournament Not Realizable by $\frac{2}{3}$-Majority Voting, and Some Open Problems in Spatial Voting Theory.*

Define the *predictability* number $\alpha(T)$ of a tournament $T$ to be the largest supermajority threshold $\frac{1}{2} < \alpha \le 1$ for which $T$ could represent the pairwise voting outcomes from some population of voter preference orders. We establish that the predictability number always exists and is rational. Only acyclic tournaments have predictability 1; the Condorcet voting paradox tournament has predictability $\frac{2}{3}$; Gilboa has found a tournament on 54 alternatives (i.e. vertices) that has predictability less than $\frac{2}{3}$, and has asked whether a smaller such tournament exists. We exhibit an 8-vertex tournament that has predictability $\frac{13}{20}$, and prove that it is the smallest tournament with predictability $< \frac{2}{3}$. Our methodology is to formulate the problem as a finite set of two-person zero-sum games, employ the minimax duality and linear programming basic solution theorems, and solve using rational arithmetic.

We conclude by advertising several open problems of computational geometry, combinatorics, and probability from spatial voting theory. (Received September 22, 2009)

1056-91-2030 **Christian P Traeger***, Department of Agric & Resource Economics, 207 Giannini Hall #3310, University of California, Berkeley, CA 94720-3310. *Risk, Uncertainty and Climate Change Evaluation.* Preliminary report.

Standard economic theory evaluates climate change on basis of a welfare function that is simultaneously additively separable in risk and time. This structure contains an implicit assumption of (intertemporal) risk neutrality, stemming from the assumption that Arrow Pratt risk aversion is equivalent to the aversion to intertemporal consumption fluctuations. Moreover, the standard model cannot capture (second order) uncertainty over probability distributions, an issue that received attention in the recent decision theoretic literature explaining observed differences in the attitude with respect to risk versus ambiguous uncertainty. This paper aims at extending the evaluation of climate change to a setting that permits a more comprehensive treatment of uncertainty accounting for intertemporal risk aversion and ambiguity. (Received September 22, 2009)

1056-91-2094 **Reginald Ford*** (`fordrk@jmu.edu`), Dept. of Mathematics and Statistics, MSC 1911, James Madison University, Harrisonburg, 22807, and **M. Vergara**, **J. C. Ortega**, **D. Melendez** and **Z. Pena**. *Mathematics Models of Mancala.*

From May 11th to June 19th five students participated in the NREUP funded Mentoring for Minorities in Mathematics ($M^3$) six week summer research program at James Madison University. The ancient board game of Mancala, popular in Africa and Asia, motivated questions in which we drew from combinatorics, strategy analysis, programming, search algorithms and basic game theory.

This talk tracks our progress over the summer, as we moved from the single player games, Tchukaillion and Tchuka Ruma, to the two player games of Ayo and Mancala, in the hopes of finding an optimal strategy. (Received September 23, 2009)

# *92 ► Biology and other natural sciences*

1056-92-43 **Jemal S Mohammed-Awel*** (`jmohammedawel@valdosta.edu`), P.O.Box 5743, Valdosta, GA 31603, and **Kbenesh W Blayneh** and **Abdul-Aziz Yakubu**. *Discrete hierarchical competition with reward and cost of dispersion.*

The dynamics of asymmetric dispersion between two patches, where the local populations are structured into m-age classes, are considered. The population in one of the patches is assumed to have age-hierarchical organization and the local population practices contest competition while the population in the other habitat is not organized and practices scramble competition. Using analytical and numerical methods, comparison of the two populations (prior to dispersion), the effects of dispersion on the persistence and extinction of the local and the metapopulation are studied as key parameters change. (Received July 08, 2009)

1056-92-54 **Anthony DeLegge*** (`s-adelegg1@math.unl.edu`) and **Steven Dunbar** (`sdunbar1@unl.edu`). *Optimal Seasonal Plant Reproduction.* Preliminary report.

In order for plants (or any living species) to have sustained survivability, reproduction is essential. However, because reproduction consumes energy, the plants, through evolution, are expected to have an optimal strategy for when to reproduce and how much energy should be devoted to reproduction so that the expected gain in biomass for the population is maximized. This evolultionary decision can be influenced by such factors as the plants' own growth rate, any environmental effects acting on the plants, the survival rate of adults from one season to the next, and the survivorship of seeds, to name a few.

With this in mind, we will present a stochastic optimization problem to model a local plant population which aims at finding a reproduction strategy that maximizes their expected adult biomass size for the following season. We will then solve it using methods from optimal control theory and then discuss, under this strategy, what should happen to the plants over a large number of seasons. (Received July 16, 2009)

1056-92-58 **Filippo Posta*** (`fposta@ucla.edu`), UCLA Medical Center, Dept. Biomathematics, Box 951766, Los Angeles, CA 90095, and **Maria R. D'Orsogna** and **Tom Chou**. *Enhancement of cargo processivity by cooperating molecular motors.*

Cellular cargo can be bound to cytoskeletal filaments by multiple molecular motors. Recent experiments have shown that the presence of auxiliary, nondriving motors, results in an enhanced processivity of the cargo, compared to the case of a single active motor alone. We model the observed cooperative transport process by a stochastic model that describes the dynamics of two molecular motors, an active one that moves cargo unidirectionally along a filament track and a passive one that acts as a tether. Analytical expressions obtained from our analysis are fit to experimental data to estimate the kinetic parameters of our model. Our analysis reveals two qualitatively distinct processivity-enhancing mechanisms: the passive tether can decrease the typical detachment rate of the active motor from the filament track or it can increase the corresponding reattachment rate. Our estimates show that in case of microtubular transport, a higher average run length arises from the ability of the passive motor to keep the cargo close to the filament, enhancing the reattachment rate of an active kinesin motor that has recently detached. For myosin-driven transport along actin, the passive motor tightly tethers the cargo to the filament, suppressing the detachment rate of the active myosin. (Received July 20, 2009)

1056-92-114 **John G Alford*** (`jalford@shsu.edu`), Box 2206, Huntsville, TX 77341, and **Bill Lutterschmidt**. *Modeling the Movements of a Thermoregulating Timber Rattlesnake.* Preliminary report.

Poikilothermic ectotherms are those animals whose body temperatures fluctuate with ambient environmental temperatures. However, some ectotherms have evolved the behavioral ability to thermoregulate their body temperature around a preferred or "set" temperature. Thermoregulatory behaviors may range from body positioning to shuttling within preferred microhabitats to find appropriate environmental temperatures. We have modeled the movement and shuttling behavior of the timber rattlesnake (Crotalus horridus) within a microhabitat. Movements depend on the temperature distribution within the microhabitat and the desire to precisely maintain a "set" temperature. Timber rattlesnakes use a sit-and-wait foraging strategy and passively thermoconform to their environment. We quantify the movements required and the potential energetic cost for timber rattlesnakes to actively thermoregulate. The model will be used to study and evaluate the behavioral life history strategies of sit-and-wait versus active foraging behaviors and the metabolic energy budgets associated with snakes that thermoconform versus actively thermoregulate within a habitat. (Received July 28, 2009)

1056-92-132 **Rachel S Nancollas*** (`rachel.nancollas@students.olin.edu`), Olin College, MB 327, 1000 Olin Way, Needham, MA 02492, and **Benjamin Y Small**. *Structural Adaptation of Microvascular Networks.* Preliminary report.

Blood vessels are not static conduits—in response to changing hemodynamic and metabolic conditions, they alter their geometry so that the body can provide oxygen and other metabolites to its tissues. In this presentation, we briefly describe a model for structural adaptation of microvessels in which the diameter and width of every vessel is governed by a coupled system of differential equations. We also discuss a model for blood flow in a microvascular network in which the flow depends on the hydraulic resistance of every vessel in the network. We then analyze the adaptation of vessels in a small network and demonstrate that equilibrium is described by a system of nonlinear equations. We discuss our method for solving these nonlinear equations and show that depending on the network parameters, a variety of equilibria exist. (Received July 29, 2009)

1056-92-170 **fatemeh emdad*** (`faemdad@utmb.edu`), 1042 Gladstone dr, League City, TX 77573, **clarisse djukom**, TX, and **david n herndon** and **marc g jeschke**. *Influence of inhalation injury on mortality of burn patients.*

Despite recent advances in burn care, advances in the management of inhalation injury have faltered. The objective of this study was to examine and compare the outcomes of patients with inhalation injury versus patients without inhalation injury in a large prospective multi-center trial.

Patients with an inhalation injury had a greater overall rate of mortality (20% vs. 9%; $p<0.001$). Patients with the probability of having inhalation injury have the highest risk of dying. Death among patients with inhalation injury and patients without inhalation injury was attributed to multiple organ failure (26% and 14%) or sepsis (24% and 33%). Patients with inhalation injury had a respiratory rate higher than patients without inhalation injury. The average (SD) highest respiratory rate for patients with inhalation injury was 29(12) vs. 26(7) for patient without inhalation injury, also the average lowest respiratory rate for patients with inhalation injury was 18(10) vs. 16(7). Compared to patients with like size burns, patients with inhalation injury are at greater risk of mortality, require longer periods in the intensive care unit as well as in the hospital prior to discharge. Surprisingly, patients with inhalation injury do not require more days spend on ventilation. (Received August 11, 2009)

1056-92-227 **Adam R. Lucas*** (`arl3@stmarys-ca.edu`), San Francisco, CA 94115. *A fixed point theorem for a general epidemic model.*

We provide a rigorous axiomatic framework to study the critical behavior of disease spreading on top of a complex network. A necessary and sufficient condition for our general epidemic model to undergo a phase transition is proven. It is known that an *epidemic state* undergoes a phase transition when the infection rate surpasses the epidemic threshold. However, for networks having degree-degree correlations, the epidemic threshold has never formally been defined. We define the epidemic threshold as, $\lambda_c := 1/\lambda'$ with $\lambda'$ denoting the largest positive eigenvalue of an operator $T$ given in the axioms of our model. When the *epidemic state* is a strictly positive solution to a fixed point equation our model is guaranteed to have a single phase transition. Percolation as well as SIS/SIR epidemic models on complex correlated networks satisfy the axioms of our model. A benefit of our axiomatic framework is that it highlights commonalities in a variety of interacting particle systems. (Received August 17, 2009)

1056-92-244 **Ardith W El-Kareh** and **Leslie B Jones*** (`ljones@math.arizona.edu`), P.O. Box 245051, University of Arizona, Tucson, AZ 85724, and **Timothy W Secomb**. *Additive damage model for anti-cancer drug combinations.*

Dose-response data for anti-cancer drugs acting in combination on cell lines are routinely used to assess whether further development in animal models or clinical trials is merited. Several mathematical models have been proposed to describe such data, including the Chou-Talalay median effect model, the Syracuse-Greco model, and the White et al surface response model. We present the additive damage model, in which survival relative to controls is described by a cumulative lognormal function of total damage, which is a linear superposition of damage terms for each drug. This reflects the distribution of lethal thresholds of total damage across the cell population. Two key features of the model are saturation effects in the drug concentration, and the difference in heterogeneity of the lethal damage threshold between the two drugs. (Received August 19, 2009)

1056-92-310 **David Isaacson*** (`isaacd@rpi.edu`), Professor David Isaacson, Mathematical Sciences Department, Rensselaer Polytechnic Institute, Troy, NY 12180, and **J. C. Newell** and **G. C. Saulnier**. *Inverse boundary value problems arising in the diagnosis and treatment of heart disease and breast cancer.*

We explain how the problems of diagnosing breast cancer and heart disease motivated the design of our Adaptive Current Tomography systems. These systems apply currents and voltages to portions of a body and reconstruct and display the electrical properties of the tissues inside the body. It will be explained how the problem of imaging these electrical properties inside the body gives rise to inverse boundary value problems for Maxwell's equations. We will describe several methods for approximately solving these inverse boundary value problems. The talk will include images and movies of cardiac activity and breast cancers made by our ACT systems. It will conclude with a description of results from recent patient studies at Mass. General Hospital. (Received August 27, 2009)

1056-92-325 **Jeremy E Brooks*** (`zjeb48@goldmail.etsu.edu`), PO Box 13711, Johnson City, TN 37614. *Time to Failure: A Stochastic Model of the Formation and Development of Abdominal Aortic Aneurysms.* Preliminary report.

Abdominal aortic aneurysms are occurring more frequently in today's older population. This talk presents a mathematical model that describes the progression of abdominal aortic aneurysms. The model examines the interactions of four key species - collagen, elastin, smooth muscle cells, and inflammatory markers - involved in the development of the disease. The stochastic model simulates the disease moving through a section of the arterial wall until the aorta reaches a critical point at which it can no longer withstand the hemodynamic pressures placed on it by the heart and consequently ruptures. The results give the mean and standard deviation of the time it takes for the aorta to reach the critical point of rupture. More importantly, the results show that a model of this type could be used to give cardiologists a better time frame for when varying types of intervention should be taken. (Received September 11, 2009)

1056-92-385 **Jeremy J Thibodeaux*** (`jthibodeaux@uco.edu`), University of Central Oklahoma, Mathematics and Statistics, 100 N University Dr., Edmond, OK 73034. *Seeking Optimal Treatment Strategies for Malaria Infection.* Preliminary report.

The malaria parasite inhibits erythropoiesis in two major ways. The first, and obvious way, is the preying upon erythrocytes. But it has been recently discovered that a toxic by-product of digested hemoglobin, called hemozoin, inhibits the development of erythroid precursors. A mathematical model accounting for both of these effects will be presented along with model predictions concerning combined treatments for both of the effects of malaria infection on the erythropoietic system. (Received September 03, 2009)

1056-92-409 **Dalin Tang*** (dtang@wpi.edu), 100 Institute Road, Math Dept, Worcester, MA 01609, and **Chun Yang**, **Tal Geva** and **Pedro del Nido**. *Two-Layer Human Right Ventricle Models with Patch and Anisotropic Material Properties for Ventricle Remodeling and Pulmonary Valve Replacement Surgical Optimization: Flow and Stress Analysis.*

Conventional pulmonary valve replacement (PVR) surgery has yielded mixed results, with many of the patients seeing little improvement in right ventricular (RV) function. An image-based modeling procedure is introduced to provide accurate assessment of RV function and test the hypothesis that more aggressive scar tissue removal using computer-aided surgery design and optimized post-operative RV morphology and patch design may lead to improved recovery of RV function. Pre- and post-operative cardiac magnetic resonance (CMR) imaging data from patients who underwent PVR were acquired for model construction. CMR-based anisotropic fluid-structure interaction models with two-layer structure for RV and LV wall and tissue fiber orientation were constructed and validated by CMR data. Computational simulations with different surgical options (virtual surgery) were performed to assess RV cardiac function, flow pattern and stress/strain conditions. Our initial results indicated that computationally optimized small patch model with aggressive scar tissue trimming yielded 10% improvement in RV ejection fraction ratio, and 20-40% lower stress/strain level in the patch region, compared with the conventional patch design. This research was supported by NIH/NHLBI grant R01HL089269. (Received September 04, 2009)

1056-92-413 **Thanate Dhirasakdanon*** (thanate@asu.edu), School of Mathematical and Statist. Sciences, Arizona State University, Tempe, AZ 85287-1804, and **Horst R Thieme**. *Infectious diseases in amphibians: adults as reservoir for epidemics in larvae.*

We consider a model for an epidemic in tiger salamander populations in Arizona caused by a lethal, directly transmitted ranavirus. The salamander has two very distinct live stages: aquatic larvae and terrestrial adults. Since the larvae are only present during parts of the year (the ponds dry up in summer), and since the adults are too dispersed to allow frequent disease transmission, the virus would have difficulty persisting in just one stage alone. Yet, recurrent epidemics have been observed. An hypothesis has been proposed (Brunner et al., 2004) in which one stage (terrestrial adults) may act as a reservoir for an epidemics in another stage (aquatic larvae). We try to corroborate this hypothesis by a mathematical model. Since strong seasonality is involved, we work with a metered (or sequential-continuous, or semi-discrete) model, which is a difference equation where the right hand side involves the time map of a differential equation. We derive conditions for the virus to persist in the salamander population, and also conditions for the virus to gradually disappear from the salamander population. (Received September 04, 2009)

1056-92-416 **Ronald E. Mickens*** (rohrs@math.gatech.edu), Physics Department, Box 1744, Atlanta, GA 30314, and **Sandra Rucker** (srucker@cau.edu), Department of Mathematical Sciences, Room 138, Atlanta, GA 30314. *Construction and Analysis of a New SIR Model.*

Standard SIR epidemiological models have the property that the infectious population numbers only go to zero as $t \to \infty$. We demonstrate, by an explicit construction, that models can be formulated such that $I(t)$ becomes zero at a finite time. Both analytical and numerical results are given to support this conclusion. (Received September 05, 2009)

1056-92-417 **Chun Yang*** (yangchun@bnu.edu.cn) and **Dalin Tang** (dtang@wpi.edu), 100 Institute Road, Math Dept, Worcester, MA 01609, and **Gador Canton**, **Thomas S. Hatsukami** and **Chun Yuan**. *Human Carotid Plaque Progression Correlated Positively with Flow Shear Stress and Negatively with Plaque Wall Stress: 3D FSI Models Using Multi-Year Patient-Tracking In Vivo MRI.*

It is well-known that atherosclerotic plaque initiation and early progression correlate negatively with flow shear stresses (FSS). Mechanisms governing advanced plaque progression may be different due to changes in flow and plaque wall stress (PWS) environment. Multi-year in vivo MRI data were acquired from 6 patients with informed consent obtained. Each patient was scanned 3-4 four times (scan interval: 18 months). Fifteen time pairs were formed for analysis, with MRI slices matched (100 data points per slice). Plaque progression was defined as wall thickness increase (WTI) at each data point. 3D fluid-structure-interaction (FSI) models were constructed for each plaque and solved to obtain PWS and FSS at 700-900 data points per time pair. Using PWS and FSS values from the "current" scan, 12 out of 15 time-pairs showed negative correlation between PWS and WTI (mean Pearson correlation coefficient r = - 0.253). Ten out of the 15 cases showed positive correlation between FSS and WTI (mean Pearson correlation coefficient r = 0.208). Results from this study indicated that correlations between plaque progression and mechanical FSS and PWS for advanced plaques may differ from

that for plaques at earlier stage. This research was supported in part by NSF grant DMS-0540684. (Received September 05, 2009)

1056-92-432 **Dana Paquin*** (dpaquin@calpoly.edu), Department of Mathematics, California Polytechnic State University, San Luis Obispo, CA 93407, and **Doron Levy** and **Lei Xing**. *Multiscale Registration of Planning CT and Daily Cone Beam CT Images for Adaptive Radiation Therapy.*

Adaptive radiation therapy is the incorporation of daily images in the radiotherapy treatment process. Registration of planning images with daily images is an important component of ART. We report our research on multiscale registration of planning CT images with daily CBCT images. The multiscale algorithm is based on the hierarchical multiscale image decomposition of Tadmor et al., A multiscale image representation using hierarchical $(BV, L^2)$ decompositions. Registration is achieved by decomposing the images to be registered into a series of scales using the $(BV, L^2)$ decomposition and initially registering the coarsest scales of the image using a landmark-based registration algorithm. The resulting transformation is then used as a starting point to deformably register the next coarse scales with one another. This procedure is iterated, at each stage using the transformation computed by the previous scale registration as the starting point for the current registration. We present the results of studies of rectum, head-neck, and prostate CT-CBCT registration, and validate our registration method quantitatively and qualitatively. (Received September 07, 2009)

1056-92-460 **Timothy D Comar*** (tcomar@ben.edu), 5700 College RD, Lisle, IL 60532, and **Pinal Shah**. *The Dynamics of One-Predator Two-Prey Systems for Integrated Pest Management.* Preliminary report.

We will describe variations of one-predator two-prey systems and present results about permanence and the dynamics of these systems. Such systems are important in integrated pest management strategies. (Received September 08, 2009)

1056-92-466 **Anna Mummert*** (mummerta@marshall.edu), Mathematics Department, Marshall University, One John Marshall Drive, Huntington, WV 25755, and **Sydney Mkhatshwa**. *Super-spreading events in infectious diseases.* Preliminary report.

Super-spreading events for a specific infectious disease are infected individuals who infect more than the average number of secondary cases. Super-spreading events pose a serious threat to public health and their influence on the course of diseases must be studied. The existence of super-spreading events has been known for many years, but they have not been studied specifically in disease modeling. The 2002-2003 outbreak of severe acute respiratory syndrome (SARS) brought the notion of super-spreading events to the forefront of epidemiological modeling. In this talk, we present and study a modified SIR disease model that captures the effect of super-spreading events in infectious diseases. (Received September 08, 2009)

1056-92-491 **Eric Todd Quinto*** (todd.quinto@tufts.edu), Department of Mathematics, Tufts University, 503 Boston Ave., Medford, MA 02155, and **Hans Rullgard** (hansr@math.su.se), Department of Mathematics, University of Stockholm, Stockholm, Sweden. *Local Singularity Reconstruction from Integrals over Curves in $\mathbb{R}^3$ and electron microscopy.* Preliminary report.

We define a general curvilinear Radon transform in $\mathbb{R}^3$, and we develop the microlocal properties of this transform. Singularities can be added in any backprojection reconstruction method for this transform. We use the microlocal properties to develop a local backprojection reconstruction algorithm that decreases the effect of the added singularities and reconstructs boundaries and contours of the object. This work is motivated by new models in electron microscope tomography in which the electrons travel over curves such as helices or spirals. We provide reconstructions for a specific transform motivated by this electron tomography problem. (Received September 09, 2009)

1056-92-501 **Suzanne Sumner*** (ssumner@umw.edu), 1301 College Ave, Fredericksburg, VA 22401, and **Wyatt A. Mangum** (wmangum@umw.edu), 1301 College Avenue, Fredericksburg, VA 22401. *Mathematical Modeling of Data describing Worker Bee Aggression towards a Foreign Queen.*

When introducing a foreign queen into a colony, worker bees often display hostility known as balling. Ideally, the number of balling bees exponentially decays to zero before the queen's release; if not, she may be killed. Prior experimental work indicates that attendant bees increase balling duration and are associated with other erratic balling patterns. An initial deterministic model displays chaotic dynamics that mimic some of the aggression behaviors, but not other behaviors. Random disturbances could be the cause of these other behaviors and the prior deterministic model is modified to include a stochastic term. Both mathematical models give the number of ballers on the introduction cage as a function of time. The results of the deterministic model and several runs of the stochastic model are compared to experimental data. Including the stochastic term simulates noisy fluctuations and aggressive patterns called reversions observed in the experimental data. This stochastic model is a first step at understanding the importance of the random initiation and cessation of balling among individual bees. Understanding how to minimize these uncertainties can make queen introduction more reliable with fewer queen losses. (Received September 10, 2009)

1056-92-531 **Shantia Yarahmadian*** (syarahmadian@math.msstate.edu), **Sidney L. Shaw**, **Kevin Zumbrun** and **Blake Barker**. *Existence and stability of steady states of a reaction convection diffusion equation modeling microtubule formation.* Preliminary report.

We have generalized the Dogterom-Leibler 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. Using this model, we study the stability of the end-sates by looking at the boundary conditions. We also study the effect of nucleation rate in the form of convection term in the complex stability of the system which leads to new steady-states. In addition, stability analysis studies, uses the Evans function framework as a new mathematical tool in the study of microtubules dynamic. The equations are:

$$\begin{aligned}
\frac{\partial p^+(x,t)}{\partial t} &= -\frac{\partial(\nu^+ p^+(x,t))}{\partial x} - f_+^- p^+(x,t) + f_-^+ p^-(x,t) + d\frac{\partial^2 p^+(x,t)}{\partial x^2}\\
\frac{\partial p^-(x,t)}{\partial t} &= \nu^- \frac{\partial p^-(x,t)}{\partial x} + f_+^- p^+(x,t) - f_-^+ p^-(x,t) + d\frac{\partial^2 p^-(x,t)}{\partial x^2}\\
\frac{\partial c(x,t)}{\partial t} &= -kc(x,t) + \nu^- p^-(x,t) - \nu^+ p^+(x,t) + D\frac{\partial^2 c(x,t)}{\partial x^2}.
\end{aligned}$$

In these equations, $c(x,t)$ represents the concentration of the free tubuline, $k$ is the hypothetic nucleation rate, $f_-^+ = \omega c(x,t)$ and $\nu^+ = u^+ c(x,t)$. (Received September 11, 2009)

1056-92-603 **Jim M Cushing*** (cushing@math.arizona.edu), Department of Mathematics, 617 N Santa Rita, University of Arizona, Tucson, AZ 85721. *The fundamental bifurcation theorem for Darwinian matrix models.* Preliminary report.

Matrix models of the form $x(t+1) = P(x(t))\, x(t)$ are used to describe the (discrete time) dynamics of structured populations. I will show how one can extend the Fundamental Bifurcation Theorem for such matrix models to Darwinian matrix models. A Darwinian matrix model is an (evolutionary game theoretic) extension of a population model which accounts for evolution that results when a phenotypic trait $u$ is subject to natural selection. Secondly, for Darwinian matrix models I will show how the basic properties of the fundamental bifurcation can be ascertained either by means of the inherent growth rate $r$ or the inherent net reproductive number $R_0$. This result is not obvious because in general there is no particular relationship between the monotonicity and concavity properties of $r = r(u)$ and $R_0 = R_0(u)$ as functions of the trait $u$. This result can be a significant aid to the study of Darwinian matrix models since $R_0$ is typically more mathematically tractable than $r$. I'll illustrate this with some applications. (Received September 14, 2009)

1056-92-614 **Hannah L Callender*** (callende@up.edu), University of Portland, Department of Mathematics, 5000 Willamette Blvd, Portland, OR 97203, and **Hans G Othmer**. *Integrin Dynamics in Motile Cells: A Stochastic Approach.* Preliminary report.

Cell motility is an essential process in the life cycle of many organisms, with implications in areas such as wound healing, the immune response, embryonic development, and cancer cell metastasis. Severe consequences such as mental retardation, vascular disease, tumor formation, and metastasis may occur when a cell's motility mechanisms malfunction. Therefore, an understanding of these mechanisms may lead to the development of novel therapeutic strategies for controlling, for example, invasive tumor cells.

Integrins are cellular surface receptors which serve both as the physical linkage between a cell and its surroundings and as signal carries to and from the cell's environment. As a cell moves across a substrate, integrins diffuse throughout the cell and cluster to help form protein complexes known as focal adhesions. In migration, these focal adhesions serve as the "feet" of the cell. Many questions exist as to how initial clustering takes place and, further, how initial clusters result in larger, more stable focal adhesions. Here we present a mathematical model to describe the initial process of integrin clustering, in effort to better understand early stages of cell motility. (Received September 14, 2009)

1056-92-627 **V Arunachalam*** (aviswana@uniandes.edu.co), Department of Mathematics, Bogota, Bogota AA 4976, Colombia. *Stochastic Modeling of The Loss of Telomere Sequences.*

Telomeres are central elements in aging and cancer. Due to the absence of telomerese, each time that the cell is divided, it loses telomere sequences. Consequently, the length of the DNA is critically reduced and it directs the cell to stop its division, entering a senescence state. Variability of the individual cells is an important consideration in the description of population. Age structured models allows such a description, for instance age of cell determines its telomere loss rate. Thus a realistic description of the population growth and telomere shortening requires an age-dependent model. This paper develops with an age-dependent model of telomere shortening in the cell to study the telomere loss in cell culture. Product density approach provides an elegant method in obtaining the moments of the numbers of telomere losses in cells. (Received September 14, 2009)

1056-92-701 **L. R. Ritter*** (lritter@spsu.edu), 1100 S. Marietta Pkwy, Mathematics, Marietta, GA 30060, and **A. I. Ibragimov** and **J. R. Walton**. *The effects of boundary transport and anti-oxidants on stability of a model of atherogenesis.*

Atherogenesis is the onset of the disease atherosclerosis. The disease is 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 (LDL) within the arterial wall and its corruptive effect on the immune process. We propose a model consisting of a system of reaction-diffusion equations characterizing the interaction of various cells and chemical species involved in the disease process. A linear stability analysis using an energy estimate approach is presented. The effects of boundary transport of immune cells and LDL as well as the presence of anti-oxidants on stability are considered. (Received September 16, 2009)

1056-92-730 **Alex Capaldi*** (alex_capaldi@ncsu.edu), Campus Box 8213, NC State University, Raleigh, NC 27695-8213, and **A. L. Lloyd**. *Parameter Estimation and Uncertainty Quantification for an Epidemic Model.*

We examine estimation of the parameters of Susceptible-Infective-Recovered (SIR) models in the context of least squares. We review the use of asymptotic statistical theory and sensitivity analysis to obtain measures of uncertainty for estimates of model parameters and thebasic reproductive number ($R_0$) - an epidemiologically significant parameter grouping. We find that estimates of different parameters, such as the transmission parameter and recovery rate, are correlated, with the magnitude and sign of this correlation depending on the value of $R_0$. Situations are highlighted in which this correlation allows the basic reproductive number to be estimated with greater ease than its constituent parameters. Uncertainty estimates and sensitivity analysis are used to investigate how the frequency at which data is sampled affects the estimation process and how the accuracy and uncertainty of estimates improves as data is collected over the course of an outbreak. We assess the informativeness of individual data points in a given time series with a view to better understanding when more frequent sampling (if possible) would prove to be most beneficial to the estimation process. This technique can be used to design data sampling schemes in a general context. (Received September 16, 2009)

1056-92-740 **Sophia R-J Jang*** (sophia.jang@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409. *Discrete host-parasitoid models with Allee effects and age structure in the host.*

We study a stage-structured single species population model with Allee effects. The asymptotic dynamics of the model depend on the maximal growth rate of the population as well as on its initial population size. We also investigate two models of host-parasitoid interaction with stage-structure and Allee effects in the host. The parasitoid population may drive the host population to extinction in both models even if the initial host population is beyond the Allee threshold. (Received September 16, 2009)

1056-92-786 **James F Selgrade*** (selgrade@math.ncsu.edu), North Carolina State University, Box 8205, Raleigh, NC 27695-8205. *Bifurcation analysis of a model for hormonal regulation of the menstrual cycle.*

A model for hormonal control of the menstrual cycle with 41 parameters is introduced. Important changes in model behavior result from variations in two of the most sensitive parameters. One parameter represents the level of estradiol sufficient for significant synthesis of luteinizing hormone, which causes ovulation. By studying bifurcation diagrams in this parameter, an interval of parameter values is observed for which a unique stable periodic solution exists and it represent an ovulatory cycle. The other parameter measures mass transfer between the first two stages of ovarian development and is indicative of healthy ovarian growth. Changes in this parameter affect the uniqueness interval defined with respect to first parameter. Hopf, saddle-node and transcritical bifurcations are examined. To attain a normal ovulatory menstrual cycle in this model, a balance must be maintained between healthy development of the ovaries and flexibility in estradiol levels needed to produce the surge in luteinizing hormone. (Received September 17, 2009)

1056-92-817 **Janine M. Haugh*** (janine_haugh@ncsu.edu), 1110-H Lupine Ct, Raleigh, NC 27606, and **Mansoor A. Haider**. *A Reaction-Diffusion Model of Cartilage Regeneration in Cell-Seeded Scaffolds.* Preliminary report.

Articular cartilage, a connective tissue lining the surfaces of bones in diarthrodial joints (hips, knees, shoulders), provides load support, energy distribution, and lubrication but is susceptible to damage from injuries and diseases like osteoarthritis. Cartilage has a limited capacity for repair and growth that is regulated by cells, called chondrocytes, in the tissue's extracellular matrix (ECM). 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. In this study, we develop mathematical models for cartilage regeneration in the local environment of a cell seeded in a hydrogel scaffold. Radially symmetric reaction-diffusion equations describe the coupling of nutrient and matrix concentrations. Several models describe the process by which matrix proteins form ECM within the scaffold, the gel-tissue interface movement, and scaffold degradation. Numerical solutions are based on finite difference and level set methods. The results are used to conduct a parametric analysis of regeneration times in terms of biophysical, physiological, and scaffold-design parameters and can provide a framework for characterization of scaffolds in tissue engineering applications. (Received September 17, 2009)

1056-92-933 **Elinor Velasquez*** (elinor@soe.ucsc.edu), 320 Everson Drive, Santa Cruz, CA 95060. *An algorithm for predicting minimal paths between genomes.* Preliminary report.

Genomic sequencing has permitted us the opportunity to use comparative genomics to reconstruct species evolution. However, genomic diversity has made the connection between an ancestral genome and present day species computationally challenging. A genome undergoes rearrangements, translocation and speciation of genes. Just modeling the rearrangements of genes that a genome undertakes is difficult. If we try to model the rearrangements of a single chromosome to another chromosome and attempt to compute the minimum number of rearrangements that a chromosome must undergo to become another chromosome, then we have an NP-hard problem. To address this issue, we will instead construct the geodesic path between two genomes. As an example of this technique, we tackle the geodesic path between the tobacco genome and the Lobelia fervens genome using the calculus of variations. (Received September 18, 2009)

1056-92-985 **Judith E Canner*** (jecanner@ncsu.edu), Biomathematics Graduate Program, North Carolina State University, Box 8203, Raleigh, NC 27695, and **Robert R Dunn**, **Itamar Giladi** and **Kevin Gross**. *The consequences of ant behavior for the spatial population dynamics of a southern wildflower.*

Myrmecochory (dispersal of seeds by ants) is an evolutionarily and ecologically common mutualism. Most of the research on the costs and benefits of myrmecochory in North America assumes that ant-dispersed seeds are taken to, and left in, the ant nest. We have shown that seeds are often secondarily redispersed from the nest into the surrounding leaf litter. Here, we use a spatially explicit model of stage-structured population dynamics to assess the influence of secondary dispersal on spatial population dynamics. The model is a discrete-time, continuous-space model that uses an integrodifference equation to incorporate nonparametric measures of primary and secondary seed dispersal. Model analysis shows that secondary dispersal of seeds increases population spread rate by 28% and nearly doubles mean dispersal distance from the parent plant. These results demonstrate that dispersal from the parent is a primary benefit of myrmecochory in eastern North American forests. We also discuss adapting our model to investigate the possible affects of climate change on ant foraging behavior and the consequent changes in plant population fitness and spatial population dynamics. (Received September 19, 2009)

1056-92-993 **Donald Geman*** (geman@jhu.edu), 302A Clark Hall, 3400 N. Charles St., Baltimore, MD 21218. *Challenges in Computational Medicine and Biology.*

Modern biology involves analyzing very large networks of interacting molecular parts. In contrast to the "gene-centric" era, this seems to call for large-scale mathematical modeling. Even assuming biological systems exhibit general properties and are amenable to modeling, the challenges are still overwhelming, at least for having a major impact in medicine and biology. One high barrier is technical: measured against the complexity of the processes (e.g., gene regulation), and the dimension (d) of the data (e.g., DNA microarrays), the number of available samples (n) is minuscule; indeed, this "small n, large d" dilemma reaches extremes in computational biology. Another barrier is cultural: the "black box" decision rules generated by computational learning inhibit biological understanding and clinical applications. I will talk about several cases studies in attempted generalization. One is estimating the topology and statistics of signaling networks, where grand goals have overrun good sense. Another is an approach to cancer biomarker discovery based solely on orderings of mRNA concentrations and sufficiently accurate and transparent for practical diagnosis and prognosis, and for modeling pathway deregulation. (Received September 19, 2009)

1056-92-1016 **Azmy S. Ackleh*** (ackleh@louisiana.edu), Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010, and **Ross A. Chiquet**, Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010. *Competitive Exclusion in a Juvenile-Adult Model with Continuous and Seasonal Reproduction.*

We develop and analyze a 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. This is typical of amphibians where juveniles (tadpoles) live in water and adults (frogs) live on land. The cases of continuous and seasonal reproduction for the two species are considered. In both cases, we develop conditions on the invasion reproductive numbers of the two species that will lead to competitive exclusion. (Received September 20, 2009)

1056-92-1133 **Jun S Song*** (songj@humgen.ucsf.edu), Institute for Human Genetics, 513 Parnassus Avenue, Box 0794, University of California, San Francisco, San Francisco, CA 94143-0794. *The Other Half of Our Genome.*

More than fifty percent of the human genome consists of repeat sequences of various types. The bulk of these repeat sequences arose from retrotransposons which have integrated into our genome via RNA intermediates. This introductory talk describes some important aspects of retrotransposons relevant to the evolution and regulation of genes, genomic instability in cancers, and chromatin dynamics. Recent genomic data indicate that some parts of the selected remnants of retrotransposons are currently being transcribed in our genome, and the implications of these unexpected activities will be discussed. Interesting research topics will be highlighted. (Received September 21, 2009)

1056-92-1153 **Georgiy P. Karev*** (karev@ncbi.nlm.nih.gov), 3014 Homewood Pkwy, Kensington, MD 20895. *Replicator equations and the principle of minimal production of information: some applications to biological models.*

Replicator equations (RE) are among the basic tools in mathematical theory of selection and evolution. A general approach to a wide class of RE is developed. The theory gives methods for reducing original complex models to the "escort systems" of ODEs (in many cases, of a small dimension) that can be explored analytically or solved numerically. It allows us to compute explicitly the evolution of distributions, which solve the RE, and all statistical characteristics of interest of the system. The solutions of the considered class of replicator equations minimize the KL–divergence of the initial and current distributions at every instant, i.e., the production of information under time-dependent constraints, which, in their turn, can be computed explicitly due to the system dynamics. The results have potential for different applications. Applications to inhomogeneous models of global demography, the ecological model of tree stand self-thinning, inhomogeneous logistical equations and evolutionary game theory are given. References. G. Karev, On mathematical theory of selection: continuous time population dynamics. JMB, Volume 60, Issue 1 (2010), p. 107 . G. Karev, Replicator equations and the principle of minimal production of information, Bulletin of Math. Biol. (submitted) (Received September 21, 2009)

1056-92-1180 **Andrey V. Olypher*** (andrei.olifer@emory.edu), Emory University, 1510 Clifton Rd. NE, Room 2172, Atlanta, GA 30322, and **Astrid A. Prinz** (astrid.prinz@emory.edu), Emory University, 1510 Clifton Rd. NE, Room 2105, Atlanta, GA 30322. *Geometry and Dynamics of Activity-Dependent Homeostatic Regulation in Neurons.*

Activity-dependent homeostatic regulation (ADHR) maintains robust neuronal functioning in the face of intra- and extracellular perturbations. Such regulation is critical for normal processing of the nervous system, avoiding pathological states such as seizures, and recovering from injuries, for example caused by stroke. The physiological mechanisms of ADHR are complex and mostly unidentified. Known mathematical models of ADHR mimic experimental data but limitations and mathematical properties of these models are poorly understood. To understand ADHR better, we set and solve a prototypical homeostatic regulation problem for a classical Morris-Lecar neuronal model. We solve the problem by separating fast neuronal and slow regulatory dynamics. The success or failure of regulation is determined by considering the bifurcation diagram of the averaged fast system and the manifolds of the regulated parameters. The obtained results are discussed from the control theory perspective. Our work clarifies existing models and formulates specific questions for future experimental and theoretical studies of ADHR. (Received September 21, 2009)

1056-92-1197 **Azmy S Ackleh** and **Paul Leonard Salceanu*** (`pls8855@louisiana.edu`), 416 Kim Dr., Lafayette, LA 70503, and **Baoling Ma**. *Coexistence of Ecotypes in a Quasilinear Size-Structured Population Model.* Preliminary report.

We investigate coexistence (in the sense of uniform persistence) of all ecotypes in a quasilinear size-structured population model of McKendrick - von Foerster type. By choosing specific forms of the growth, mortality and reproduction functions, we integrate the PDE model to obtain a $2n$-dimensional ODE model for which we focus on the case when individuals of ecotype $j$ may produce offspring of ecotype $i$ with probability $\gamma_{ij}$. We show that if the stochastic matrix $(\gamma_{ij})_{1\leq i,j\leq n}$ is irreducible then coexistence of all ecotypes is possible, provided that the extinction equilibrium point is unstable in the linear approximation. In the end, we provide numerical simulations that address the outcome of the model in the case when $(\gamma_{ij})_{1\leq i,j\leq n}$ is reducible, but each of its block-diagonal components is irreducible. (Received September 21, 2009)

1056-92-1215 **Jonathan L Mitchell*** (`jmitchell@smu.edu`), 9821 Summerwood Circle #1502, Dallas, TX 75243. *Synchronous versus Asynchronous Oscillations for an Antigenically Varying Plasmodium falciparum Infection with Host Immune Response.* Preliminary report.

We consider a deterministic intrahost model for *Plasmodium falciparum (Pf)* Malaria Infection which accounts for antigenic variation between $n$ clonal variants and corresponding host immune effectors. Specifically, the model separates the immune response into two components, specific and cross-reactive, respectively, in order to demonstrate that the latter can be a mechanism for the sequential appearance of variants observed in actual *Pf* infections. We show that this sequential dominance lengthens infection time and is, thus, considered a survival strategy for the parasite. We also incorporate a constant delay or time lag in the stimulation of immune response which represents the time between changes in the *Pf* population and production of immune effectors. We find two possible critical delay times which lead to an Hopf bifurcation, one for persistent synchronized oscillations while the other for persistent antiphase oscillations. Conditions for which case occurs "first" are given along with bifurcation behavior near the critical values. (Received September 21, 2009)

1056-92-1239 **Ruijun Zhao*** (`rzhao@purdue.edu`), 205 N. University Street, West Lafayette, IN 47907-2107, and **Fabio A. Milner** (`Fabio.Milner@asu.edu`), Arizona State University, School of Mathematical and Statistical Scienc, P.O. Box 871804, Tempe, AZ 85287-1804. *Is the resurgence of syphilis a backward bifurcation?*

Syphilis was believed to disappear in US and other developed countries after the effective treatment by penicillin half a century ago. However, recent resurgence of syphilis in several communities questions the effectiveness of medical treatment in controlling the spread of the disease. In particularly, whether the resurgence signals cycling from the point view of mathematical modeling is under debate.

We study a mathematical model of syphilis, incorporating the fact of partial immune protection after treatment and behavioral protection through education. Our model suggests that a backward bifurcation can occur if a condition is satisfied. The resurgence of syphilis could be a result of changes of behavioral protection among the "high risk" group. (Received September 21, 2009)

1056-92-1240 **Jan Rychtar*** (`rychtar@uncg.edu`), Department of Mathematics and Statistics, University of North Carolina at Greensboro, Greensboro, NC 27410. *Evolutionary dynamics on undirected graphs - the effect of graph structure and initial placement on mutant spread.*

We study how the fixation probability of a mutant in a finite population in stochastic birth-death dynamics depends on the initial placement of a mutant. In particular, we study how the outcome depends on the degree of the vertex where the mutant is introduced. We give explicit formulae for fixation probabilities in the case of random drift (with mutants identical to the resident population) and also give approximations of relative fixation probabilities for general case. Further, we explore which types of graphs are conducive to mutant fixation and which are not. (Received September 21, 2009)

1056-92-1295 **Laurentiu Mircea Sega*** (`lsega@purdue.edu`), 800 Timber Trail Dr, Apt 808, Lafayette, IN 47905, and **Fabio Augusto Milner**. *Combining immunological and epidemiological models.* Preliminary report.

For many decades mathematical models have been used to describe and analyze the evolution of epidemics through populations. Some are simple ODE-based models that contain only the relevant epidemiological variables ( infected, recovered, susceptibles, latently infected, etc), while others introduced several structural variables (size, age, gender).In the same time there were a number of models proposed to analyze the response of the immune system at the individual level. We will develop a general framework to combine these types of models. We will use immunological variables as structural variables of epidemiological models. This will lead to coupled systems of ordinary and partial differential equations with boundary conditions. We will apply this general setting to analyze a model for the spread of HIV. We will describe an SIR model with several structural variables of immunological nature, namely T-cell density, infected T-cell density and virus density. We will present a proof for the existence of solutions and also provide simulation results. (Received September 21, 2009)

1056-92-1325 **Eric R Kaufmann*** (erkaufmann@ualr.edu), Department of Mathematics and Statistics, 2801 S. University Ave., UALR, Little Rock, AR 72204. *A Ratio Dependent Predator-Prey System on a Time Scale.* Preliminary report.

We consider a ratio dependent predator-prey model on a time-scale. (Received September 21, 2009)

1056-92-1396 **Yiding Yang*** (yang@math.purdue.edu), Department of Mathematics, Purdue University, 150 N. University Street, West Lafayette,, IN 47907, and **Zhilan Feng**, **Dashun Xu** and **Dennis Minchella**. *Effect of host heterogeneity on the coevolution of parasite and host.*

A system of differential equations which models the disease dynamics of schistosomiasis is used to study the evolution of parasite virulence. The model incorporates both the definitive human hosts and two strains of intermediate snail hosts. An age-structure of human hosts is considered to reflect the age-dependent transmission rate and age-targeted drug treatment rate. The basic parasite reproductive number $\Re_i$ of strain $i$ snail hosts is computed, and the invasion reproductive number $\Re_{ij}$ for strain $i$ snail host when type $j$ snail hosts are at the equilibrium. We establish the criterion for strain $i$ to invade strain $j$ snail host, and the criterion is used to examine the evolutionary dynamics of snail hosts and the parasite. (Received September 21, 2009)

1056-92-1411 **Michel Tchuenche*** (jtchuenc@uoguelph.ca), Department of Mathematics and Statistics, University of Guelph, 50 Stone Road East, Guelph, ON N1G 2W1, Canada, **A.P. Galvani**, Department of Epidemiology and Public Health, Yale University School of Medicine, New Haven, CT, **L. Ancel-Meyers**, Section of Integrative Biology &, Institute for Cellular and Molecular Biology, The University of Texas at Austin, Austin, TX 78712, and **Chris Bauch**, Department of Mathematics and Statistics, University of Guelph, Guelph, Guelph, ON N1G 2W1, Canada. *Outbreak control through voluntary first-order and second-order ring vaccination.* Preliminary report.

In ring vaccination, the contacts of an index case are identified and vaccinated. This has been applied in modelling the control of various infectious diseases. However, a form of ring vaccination where both contacts of index cases and some fraction of the contacts of the contacts of the index cases (second-order contacts) has not been explored. This may be a successful policy option for diseases where individuals are infectious before exhibiting symptoms, such as influenza, in health care systems with well-developed contact tracing capabilities. We derive and analyze a simple mathematical model that represents the conditions for control of an infectious disease through first-order and second-order ring vaccination, where individuals are free to choose whether or not to vaccinate and decide according to utility (health) maximization in the context of the vaccination decisions of others with whom they are in contact. (Received September 21, 2009)

1056-92-1412 **Chang Hyeong Lee*** (chlee@unist.ac.kr), Mechanical and Advanced Materials Engineering, UNIST, 100 Banyeon-ri,Eonyang-eup,Ulju-gun, Ulsan City, 689-798, South Korea. *A moment closure method for stochastic biochemical networks.*

If a stochastic biochemical network contains nonlinear reactions, it is difficult, if not impossible, to find a solution of the chemical master equation for the network. Thus, researchers often resort to finding the first moment or mean and the second central moment or covariance instead of the probability distribution, since they give decent description for the stochastic dynamics such as average quantity and fluctuation. However, due to the nonlinear reactions, the equations for any moments always include higher moment terms. As a result, to find the two lowest moments, one has to deal with an infinite dimensional system of ODEs for all moments. In this talk, we present a moment closure method that approximates an infinite dimensional ODE system for the moments by a finite dimensional ODE system. We derive an infinite dimensional ODE system for all moments and by truncation of the infinite dimensional system at certain moments, we obtain a finite dimensional ODE system. Applying conventional numerical schemes to the truncated system, we obtain numerical approximation for the two lowest moments. Furthermore, we estimate the errors generated by this approximation in a rigorous way. Lastly, we present examples to show numerical accuracy and efficiency of the approximation. (Received September 21, 2009)

1056-92-1415 **Katherine Isaacs*** (katherine.isaacs@students.sjsu.edu). *A Statistical Method for Environmental Prediction in Metagenomic Samples.* Preliminary report.

A metagenome is a sampling of genetic sequences from the entire microbial community within an environment. Examining the functional diversity represented by these sequences gives insight into the biological processes within the environment as well as the biological differences between environments. Most research has focused on single specific environments and the few comparative analyses have been based only on small homogeneous fractions of the metagenomic data which is currently available. We explore a technique using supervised Random Forests and canonical discriminant analysis to study over 200 metagenomes from varied environments. Our findings confirm this method differentiates and predicts environments accurately using only a subset of key functional hierarchies. (Received September 21, 2009)

1056-92-1506 **Valerie Hower*** (vhower@math.berkeley.edu) and **Lior Pachter** (lpachter@math.berkeley.edu). *A persistence tree-based method for calling peaks in ChIP-seq protein binding analysis.*

We present a new algorithm for analyzing ChIP-seq data. ChIP-seq is a relatively new assay for measuring the interactions of proteins with DNA. The binding sites for a given protein in a genome are “peaks” in the data, which is given by an integer-valued height function $f$ defined on the genome. We present a method for identifying statistically significant peaks in ChIP-seq data that is inspired by the notion of persistence in topological data analysis. Our method reduces the peak calling problem to the study of certain tree-based statistics derived from the data. (Received September 22, 2009)

1056-92-1524 **Reinhard Laubenbacher*** (reinhard@vbi.vt.edu), Washington St. (0477), Blacksburg, VA 24061, and **David Murragarra**, Virginia Bioinformatics Institute, Washington St. (0477), Blacksburg, VA 24061. *Nested canalyzing polynomial dynamical systems.* Preliminary report.

Discrete models of biological networks are being used increasingly in the life sciences, in particular Boolean networks. Networks constructed using certain families of Boolean functions have played a special role, in particular so-called nested canalyzing functions. It has been shown that the class of these functions is an algebraic variety parametrized by binomials. It has been shown further that this class of functions is identical to the class of unate cascade functions, which have the property that they lead to binary decision diagrams with shortest average path length. This talk presents a generalization of the concept of nested canalyzing Boolean function to polynomials over arbitrary finite fields. It is shown that the class of nested canalyzing polynomials also forms a toric variety. Furthermore, experimental evidence is presented that dynamical systems constructed from nested canalyzing polynomials have very special dynamic properties. (Received September 22, 2009)

1056-92-1567 **Kristie Llera*** (kllera@my.fit.edu), Florida Insititute of Technology, Department of Mathematical Sciences, 150 W. Univ. Blvd., Melbourne, FL 32901, and **Elif Demirci**, University of Ankara, Fen Fakultesi, Matematik Bolumu, Ankara, Turkey. *Estimating Vital Coral Population Parameters.* Preliminary report.

Coral reefs support more species than any other marine ecosystem on earth. Recent and unprecented increases in ocean temperatures have had significant social, economic, and environmental impacts. Yet, we still have a poor understanding of the fundamental processes and dynamics on reefs. We mathematically defined three vital population parameters: growth, partial mortality, and total mortality to further our understanding of how these rates affect coral population dynamics. Two approaches have produced general trends for these parameters using initial colony size to define (1) relative growth rates and (2) probability density functions. Functional relationships were determined between growth rate and initial colony size using curve fitting analysis, least-squares approximation and probability functions. Further analyses are underway to (1) determine the relationships between growth rates and corals' initial perimeter, and (2) develop differential equations in modeling the coral population using initial size and these vital population parameters. (Received September 22, 2009)

1056-92-1570 **Christina Rose Kyrtsos*** (crkyrtso@umd.edu), 2243 AV Williams Bldg, University of Maryland, College Park, MD 20742, and **John S Baras** (baras@umd.edu), 2247 AV Williams Bldg, University of Maryland, College Park, MD 20742. *A Systems Biology Approach to Modeling Alzheimer's Disease.* Preliminary report.

A mathematical model for Alzheimer's disease (AD) has been developed using a systems biology approach. A cellular network of neurons, microglia and astrocytes has been created to model the levels of beta amyloid in the brain. The production and spatial distribution of beta amyloid, the key protein implicated in AD, has been modeled using the reaction-diffusion equation, where reaction rates have been modeled using stochastic functions. Neurons have been modeled using a previously developed McCulloch-Pitts neural network modified to account for neuronal cell death and loss of synaptic elements during high beta amyloid levels. Microglia are either in the ramified state and modeled using a continuous random walk model, or in the activated state and modeled using the Langevin equation of motion. Astrocytes are defined to set locations and contribute to removal of beta amyloid from the brain interstitial fluid. The roles that local cerebral blood flow, transport across the BBB, and local reactions play have also been modeled. Future work will look at the development of amyloid beta plaques in the cerebrovasculature and brain parenchyma, and their relationship to observed decreases in cerebral blood flow as the disease progresses. (Received September 22, 2009)

1056-92-1583 **Karen Bliss*** (kmbliss@ncsu.edu), North Carolina State University, Mathematics Department, Box 8205, Raleigh, NC 27695-8205, and **H T Tran**, **H T Banks** and **Peter Kotanko**. *Development of a Model of Erythropoiesis in Patients with Chronic Kidney Disease.*

Red blood cell production (erythropoiesis) is normally regulated by the hormone erythropoietin (EPO) via a negative feedback control in the kidney. Patients with chronic kidney disease (CKD) must receive EPO and iron intravenously concurrent with hemodialysis to avoid anemia. We develop an age-structured model to describe erythropoiesis in patients with CKD and compare the model output to data. We also model overall inflammation level in the body, which affects both iron availability and survival of erythroid progenitor cells. (Received September 22, 2009)

1056-92-1649 **Prasanth George** and **John Ringland*** (ringland@buffalo.edu), 244 Mathematics Bldg, University at Buffalo, State University of New York, Buffalo, NY 14260. *Asymptotic formulas for the equilibria in a model of suppression of pest resistance to insecticidal genetically modified crops.*

We analyze a deterministic model of an insect pest population on an agricultural crop consisting of fields of genetically modified plants that are toxic to the pest and government-mandated "refuges" of conventional toxin-free plants. The model includes migration of the pest to and from a hospitable habitat distinct from the crop. It is assumed that the pest population carries a genetic allele that confers resistance to the toxin present in the crop; refuges are used with the goal of preventing a control failure due to this allele becoming predominant in the population. When the refuges are absent, an agriculturally desirable low-population equilibrium exists in some parameter regions of the model. The addition of refuges is seen to eliminate this desirable state, and can thus actually be harmful. Asymptotic formulas for the equilibria are developed in the limit of weak communication with the external habitat. The formulas show how each of the many parameters influences these agriculturally significant features. (Received September 22, 2009)

1056-92-1667 **Joseph A Rhoads*** (joseph.rhoads@gmail.com), **Richard Bertram**, **Joel Tabak**, **Michael Mascagni** and **Gordon Erlebacher**. *Biological Neronal Networks on Nvidia Cuda Graphics Processors.* Preliminary report.

Biological neuronal networks with thousands of neurons create systems with hundreds of thousands of equations that need to be updated at every time step. The structure of the system of ordinary differential equations that govern the cell dynamics lends itself to data parallel programming with CUDA. We are able to run neuron systems with thousands of cells in parallel on the GPU at a fraction of the time required for serial simulations on a workstation. (Received September 22, 2009)

1056-92-1701 **Gunnar Erik Carlsson*** (gunnar@math.stanford.edu), Mathematics Department, Stanford University, Stanford, CA 94305. *Topological methods for mapping biological data sets.*

We will discuss some methods for constructing conceptually useful qualitative maps of data sets arising in biology. The mathematics behind the methods will be discussed, as will some applications to some interesting data sets. (Received September 22, 2009)

1056-92-1728 **Jasmine Foo*** (jfoo@cbio.mskcc.org), 415 E 68th St, New York, NY 10065, and **Kevin Leder** and **Franziska Michor**. *A Multi-type Branching Process Model of Tumor Expansion.*

We consider a stochastic model of tumor expansion using multi-type branching processes. Each time a cell replicates, mutation may occur with small probability $u$. A mutation confers a change in fitness or birth rate on the daughter cell, which is randomly chosen from a specific distribution. We analyze the behavior of this process and its dependence on this mutational fitness distribution. (Received September 22, 2009)

1056-92-1763 **Abdul-Aziz Yakubu*** (ayakubu@howard.edu), Howard University, Department of Mathematics, 2441 6th Street, NW, Washington, DC 20059. *The Impact of Periodic Proportional Harvesting Policies on TAC-Regulated Fishery Systems.*

Loss of marine species affects the ability of the ocean to resist the spread of diseases, produce seafood, filter nutrients, store $CO_2$, etc. In a 2006 Journal of Science article, a group of economists and ecologists warned that the world's fish supply will run out by 2048. In this talk, we use mathematical models to study the impact of constant and periodic fishing pressures on the persistence of exploited fisheries systems. As case studies, we use Pacific Halibut and Georges Bank Cod stock data to show that under mild environmental conditions and current fishing exploitation levels, it is likely that the Pacific Halibut will persist while the cod is endangered. However, in the presence of increased weather extremes both species are endangered. We will also introduce a bioeconomic model for examining the net present value and dynamics of harvest under the optimal periodic proportion policies for the exploited fisheries systems. (Received September 22, 2009)

1056-92-1791 **John Bantle*** (jjbantle@buffalo.edu), 244 Mathematics Bldg, University at Buffalo, Buffalo, NY 14260, and **Aaron Festinger**, **Hee-Joon Jo** and **Ryan Klafehn**. *Prolonging the effectiveness of transgenic insecticidal crops.*

We use a detailed stochastic population model of the agricultural pest pink bollworm in fields of genetically modified pesticidal cotton to evaluate unconventional strategies for staving off the development of widespread resistance to the poison in the pest population. (Received September 22, 2009)

1056-92-1799 **John Dambra*** (jjdambra@buffalo.edu), 244 Mathematics Bldg, University at Buffalo, Buffalo, NY 14260, and **Steven Leuthe**. *Complex dynamics of a single nephron model with tubuloglomerular feedback and a myogenic mechanism.*

The nephron is the basic functional unit of the kidney. The rate at which the nephron filters the blood is controlled by two regulators: the tubuloglomerular feedback system and the myogenic response in the afferent arteriole. In our model we have observed complex dynamics and bifurcations arising through the interaction of these two regulators. (Received September 22, 2009)

1056-92-1807 **Shandelle M Henson*** (henson@andrews.edu), Department of Mathematics, Andrews University, Berrien Springs, MI 49104, and **J M Cushing** and **James L Hayward**. *Darwinian Dynamics of Avian Populations with Reproductive Synchrony.* Preliminary report.

Socially-stimulated oscillator synchrony has been documented in menstrual cycles of women, estrous cycles of Norway rats, and egg-laying cycles of Glaucous-winged Gulls. We probe the question of selective advantage in gulls by considering a Darwinian Dynamics model consisting of a gull population model coupled to a model for a heritable trait related to social stimulation. The Darwinian Dynamics model predicts that the system will evolve to a state for which egg-laying synchrony exists. (Received September 22, 2009)

1056-92-1833 **Ian M. Besse*** (ibesse@math.uiowa.edu), 2014 S.E. 12th Ave., #104, Portland, OR 97214, and **Colleen C. Mitchell**, **Erwin F. Shibata** and **Thomas Hund**. *Modeling Stochastic Cardiac Caveolae: a potential source of arrhythmogenic persistent sodium current in cardiomyocytes.*

Contraction of a cardiac myocyte is initiated by a transient depolarization of the cell membrane called an action potential. The electric currents which generate an action potential result from the rapid movement of ions across the membrane through pores called ion channels. Recent studies of membrane microdomains, called caveolae, reveal that caveolae are reservoirs of "recruitable" sodium ion channels. As such, caveolar channels constitute a substantial and previously unrecognized source of sodium current in cardiac cells. Additionally, links have been established between mutations in caveolin-3, the primary structural protein for caveolae, and a particular type of Long QT Syndrome (LQTS), a condition which collectively refers to any of several distinct arrhythmogenic channelopathies affecting cardiac myocyte repolarization. In this research we model caveolar sodium current contributions to the cardiac action potential and show that stochasticity in caveolae, in the absence of any channelopathy, is sufficient to produce delays in myocyte repolarization, the hallmark of LQTS. Our results suggest that alterations to caveolar opening dynamics due to caveolin-3 mutation, rather than alterations to ion channel kinetics, underlie this caveolin-related type of LQTS. (Received September 22, 2009)

1056-92-1834 **Alice L. Loth*** (aloth@umassd.edu). *Biological Data Mining and Analysis.* Preliminary report.

The rapid advance in biological knowledge and in technology has led to vast amounts of biological data that is readily available for global, multi-dimensional, visual, functional, and/or statistical analysis. This paper presents some of the techniques, difficulties and benefits of undertaking microarray data analysis. (Received September 22, 2009)

1056-92-1839 **Andrew L Nevai*** (anevai@math.ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816-1364, and **Benjamin M Bolker**, Biology Department, University of Florida, Gainesville, FL 32611-8525. *A comparison of spatial interactions at different scales.*

For a stochastic plant population model involving seed dispersal, competition between neighbors, and landscape-induced mortality, we investigate connections between a spatial point process description and a spatial logistic equation with diffusion. The spatial moment equations of the spatial point process consist of an ODE for the mean population density and a pair of coupled PDEs, one for the cross-correlation between population size and landscape mortality and one for the auto-correlation of population size. The spatial logistic equation with diffusion, which amounts to short-range dispersal coupled with local competition and mortality, has corresponding ODE and PDE equations describing the fluctuations of population density and landscape mortality around their mean values. This work is in collaboration with B Bolker. (Received September 22, 2009)

1056-92-1844 **Semen Koksal*** (skoksal@fit.edu), 150 W. Univ. Blvd., Florida Institute of Technology, Dept. of Mathematical Sciences, Melbourne, FL 32901, **Ioana Policeanu**, Department of Mathematical Sciences, Florida Insitute of Technology, and **David Carroll**, Department of Biological Sciences, Florida Institute of Technology. *A Mathematical Model for the MAPK Pathway in Starfish Oocytes.* Preliminary report.

In this talk, we will introduce a mathematical model, a system of nonlinear ordinary differential equations, which simulates the MAPK pathway, one of the most important biological cascades within the cell. Although this cascade contains numerous components, not all are accounted for in this model. Instead, we focus on the last and most important biological enzymes, Raf*, MEK and MAPK, whose input is directly derived from the initial hormone, 1-MA, which is added to the cell in order to start the cascade. This is the first model that analyzes the activation of three kinesis to 1-MA. In addition, model set up, parametric estimations and numerical simulations will be given. Comparison between the experimental and mathematical results will be discussed. (Received September 22, 2009)

1056-92-1859 **Lisa Driskell***, 150 N. University Street, West Lafayette, IN 47907. *A piecewise-defined two-variable model for cardiac tissue.*

We introduce a two-variable model developed as a modification of the popular Fitzhugh-Nagumo and Mitchell-Schaeffer models for electrical activity in excitable cells. Our model captures the major components of cardiac behavior while allowing for an explicit analysis of the propagation of electrical impulses in cardiac tissue. We examine the existence and stability of such traveling waves on varying geometries. (Received September 22, 2009)

1056-92-1869 **Suzanne Galayda*** (sgalayda@nmsu.edu) and **Ernest Barany**. *Effect of the Diffusion Coefficient on Noise Sensitivity in the Stochastic Chemostat.*

The chemostat (or continuous stirred tank reactor) is used in the investigation of microbial interactions under nutrient limitation. In this talk we discuss the derivation of a stochastic form of the corresponding mathematical model. We use two methods to derive our model. In the first we perturb one or both of the equation parameters by noise, resulting in three possible forms of the diffusion coefficient for the stochastic chemostat model. In the second we assume the existence of an underlying Markov process in the system and derive the drift and diffusion coefficients from the transition probabilities. By assuming either dependence or independence of the system parameters, we derive two additional forms for the diffusion coefficient. The effect of the form of the diffusion coefficient on the sensitivity of the system to noise is determined by comparing models numerically. Derivation methods are contrasted and the physical interpretation of each method is discussed. (Received September 22, 2009)

1056-92-1899 **Sarah Geneser*** (sgeneser@stanford.edu), 1201 Welch Road, Rm P060, Stanford, CA 94305-5488, **Stephanie L. Rutledge** (srutledge@projects.sdsu.edu), Comprehensive SDSU/UCSD Cancer Center Partner, 6363 Alvarado Court, Suite 103, San Diego, CA 92120, and **Sylvia K. Plevritis** (sylvia.plevritis@stanford.edu), 1201 Welch Rd, Rm P267, Stanford, CA 94305-5488. *Identifying Effective Age-Based Mammogram Screening Schedules Using a Stochastic Population Model of Breast Cancer.*

Breast cancer is the second leading cause of cancer death among women in the United States. Early diagnosis is essential to survival, and mammograms offer an effective means of detection. While the US Preventative

Services Task Force recommends mammography for women over 40, national and international debate considers alternative screening age intervals, with various groups advocating screening ages 40-69, 50-69, and 50-79 years. Another approach to address the age-dependent effects of screening on survival outcome is to consider age-dependent screening schedules, yet no policies do so. Moreover, little work exists on optimizing the cost-effectiveness of mammography over age-based intervals.

In our work, we compare the relative effectiveness of targeting different age-groups (40-69, 50-69, and 50-79) for screening on breast cancer mortality. Additionally, we investigate the impact of annual and biannual screening schedules by age group on mortality. To accomplish this, we employ a Markovian epidemiological model that simulates breast cancer histories for a large population of individual patients. To determine the effect of varying screening protocols, we include screening, detection, treatment, and mortality components in our computational model. (Received September 22, 2009)

1056-92-1902 **Ming-Ying Leung***, 500 W. University Avenue, Department of Mathematical Sciences, El Paso, TX 79968-0514. *Poisson Approximations for Palindrome Distributions in DNA Viral Genomes.*

Palindromes are symmetrical words of DNA in the sense that they read exactly the same as their reverse complementary sequences. Representing the occurrences of palindromes in a DNA molecule as points on the unit interval, the scan statistics can be used to identify regions of unusually high concentration of palindromes. These regions have been associated with the replication origins on a few herpesviruses in previous studies. However, the use of scan statistics requires the assumption that the points representing the palindromes are independently and uniformly distributed on the unit interval. We provide a mathematical basis for this assumption by showing that in randomly generated DNA sequences, the occurrences of palindromes can be approximated by a Poisson process. Furthermore, we propose a compound Poisson approximation for the Palindrome Length Score (PLS) as a measure of palindrome concentration in fixed-length windows in viral DNA. As this compound Poisson distribution for PLS can be explicitly computed, it provides criteria for evaluation of statistical significance of the PLS. Windows with significantly higher PLS can then be identified as likely location of replication origins. This approach has been applied to predict replication origins for herpesvirus genomes. (Received September 22, 2009)

1056-92-1911 **Christine E Heitsch*** (heitsch@math.gatech.edu), Georgia Institute of Technology, School of Mathematics, Atlanta, GA 30332-0160. *Strings, Trees, and RNA Folding.*

An RNA molecule is a linear biochemical chain which folds into a three dimensional structure via a set of 2D base pairings known as a nested secondary structure. Reliably determining a secondary structure for large RNA molecules, such as the genomes of most viruses, is an important open problem in molecular biology. Using strings and (plane) trees as a combinatorial model of RNA folding, we give mathematical results which yield insights into the interaction of local and global constraints in RNA secondary structures and suggest new directions in understanding the folding of RNA viral genomes. (Received September 22, 2009)

1056-92-1958 **Mayra Hernandez*** (mayra.alina@yahoo.com), **Isaacs Kate**, **Naneh Apkarian**, **Michelle Creek**, **Eric Guan**, **Chris Peterson** and **Todd Regh**. *Organism-Associated and Mat-Forming Metagenome Statistical Analysis using Random Forests Algorithms.* Preliminary report.

Analysis of metagenomic data clusters together specimens from given biological lines. Given the diversity of the environment, many classes result and specimens within each class tend to be viewed as though they are identical. The reality of the diversity within a class is explored in this series of analysis. We employ various supervised and unsupervised methods coupled with graphical representations to ascertain both the inherent difficulty in large metagenomic analysis (due to intra-group diversity) and to point out the high effectiveness of metagenomic analysis even in large data sets in accurately defining given environments along biologically meaningful lines, despite the difficulty introduced by intra-class diversity. These results support and fit well with findings by Dinsdale et al which was among the first to explore the possibility to define metagenomes by the susbsystem association. (Received September 22, 2009)

1056-92-1980 **Cecilia Clementi*** (cecilia@rice.edu), Department of Chemistry, Rice University, Houston, TX 77251-1892. *A Multiscale Approach to Characterize Macromolecular Dynamics and Functions.*

The understanding of emerging collective behaviors in biomolecular complexes represent a major challenge in modern biophysics. As a first step toward the study of such processes we have applied multi-resolution nonlinear dimensionality reduction to obtain reliable low-dimensional representations and models for the dynamics of apparently high-dimensional complex systems such as proteins in a biological environment. Although still preliminary, the results clearly show that the proposed methods can efficiently find low dimensional representations of a complex process such as protein folding. (Received September 23, 2009)

1056-92-2146 **Yiting Yang*** (yang36@mailbox.sc.edu), 1523 Greene Street, Columbia, SC 29208, and **Laszlo Szekely** (szekely@math.sc.edu), 1523 Greene Street, Columbia, SC 29208. *On the Expectation and Variance of the Reversal Distance.*

We give a pair of well-matched lower and upper bounds for the expectation of reversal distance under the hypothesis of random gene order by investigating the expected number of cycles in the breakpoint graph of linear signed permutations. Sankoff and Haque proved similar results for circular signed permutations based on approximations based on a slightly different model; while our approach is discrete.We also provide an near-tight upper bound for the variance of reversal distance, which gives information on the distribution of reversal distance. (Received September 23, 2009)

# 93 ► *Systems theory; control*

1056-93-407 **Rachael Miller Neilan*** (rmill48@lsu.edu), 2139 Energy, Coast, and Environment Building, Louisiana State University, Baton Rouge, LA 70803, and **Suzanne Lenhart** (lenhart@math.utk.edu). *Optimal vaccine distribution in a spatiotemporal epidemic model with an application to rabies and raccoons.*

We formulate a S-I-R (Susceptible, Infected, Immune) spatiotemporal epidemic model as a system of coupled parabolic partial differential equations with advection-diffusion movement terms and no-flux boundary conditions. Immunity is gained through vaccination. The objective is to characterize the optimal control, a vaccine distribution schedule which minimizes the number of infected individuals and the costs associated with vaccination over a finite space and time domain. Existence of solutions to the state system and existence of an optimal control are proved and the corresponding sensitivity and adjoint equations are derived. Techniques of optimal control theory are then employed to obtain the optimal control characterization in terms of state and adjoint functions. To illustrate, parameter values are chosen to model the spread of rabies in raccoons. The optimal allocation of oral rabies vaccine baits on a homogeneous domain is compared with the optimal distribution on a heterogeneous domain incorporating rivers and forest cover and long distance raccoon translocation. Numerical results reveal that natural land features affecting raccoon movement and the relocation of raccoons by humans can considerably alter the design of a cost-effective vaccination regime. (Received September 04, 2009)

1056-93-675 **Scott W. Hansen*** (shansen@iastate.edu), Department of Mathematics, Iowa State University, Ames, IA 50011. *Stability and stabilization of a multilayer beam system.*

We consider the multi-layer Rao-Nakra beam system with combinations of passive internal damping and boundary feedback. With passive internal damping alone, we can prove that the system is exponentially stable except in two exceptional cases: when all the wave speeds are the same, or when all wave speeds except one are the same and the common wave speeds match one of a sequence of critical numbers. In these cases, a single feedback on one layer is sufficient to achieve exponential stability. Related results on boundary stabilization without any internal damping are also described. (Received September 15, 2009)

1056-93-741 **Wolfgang Kliemann*** (kliemann@iastate.edu), Iowa State University, Department of Mathematics, 396 Carver Hall, Ames, IA 50011. *Optimal Parameter Tuning for Stability under Uncertainty.*

This paper considers stability of ordinary differential equations under (deterministic or stochastic) uncertainty. The uncertainty is modeled either as a set of functions with values in a given range, or as a stochastic process with values in the same range. We assume that the system has a common fixed point for all values of the disturbance, and analyze the stability of this equilibrium via Lyapunov exponents. We introduce the idea of (deterministic and stochastic) stability radii and analyze some of their properties, including the relation between radii for the original system and its linearization at the fixed point. For a given system with tunable parameters, we are interested in finding the optimal parameter value in the sense that (one of) the stability radii become maximal. As a nontrivial example we discuss a four-machine, two-area electric power system in which the tunable parameter is the gain constant of (one or two) PSS. (Received September 16, 2009)

1056-93-1006 **Lianwen Wang*** (lwang@ucmo.edu), Department of Math and Computer Science, University of Central Missouri, Warrensburg, MO 64093. *Optimality Conditions for Control Systems of Neutral Type.*

In this talk we consider optimal control of control systems governed by a class of neutral differential equations with time delays appearing in both the cost index functional and the neutral differential equations. With the help of duality scheme, we have established necessary and sufficient optimality conditions in subdifferential form. (Received September 19, 2009)

1056-93-1258 **John M Davis*** (John_M_Davis@baylor.edu), Department of Mathematics, Baylor University, Waco, TX 76638. *Lyapunov-Based Methods for Designing Stable Switched Systems.* Preliminary report.

Using algebraic and dynamic Lyapunov methods, we investigate two paradigms for designing stable switched systems: (1) when given a compact family of pairwise commuting stable matrices but the underlying graininess is a parameter, and (2) when a finite set of graininesses is specified for a single system which is discretized over the set. We compare and contrast the results and techniques in each situation and take a glimpse at associated converse Lyapunov theorems in these directions. (Received September 21, 2009)

1056-93-1622 **Ionel Michael Navon*** (inavon@fsu.edu), Dept of Scientific Computing, Dirac Sci Lib Bldg Rm#483, Florida State University, Tallahassee, FL 32306-4120, **K Alekseev Aleksey**, Moscow Institute of Physics and Technology, Moscow, 1, 41700,, Russia, and **M E Zelentsov**, Moscow Institute of Physics and Technology, Moscow, 41700,, Russia. *The Estimation of functional uncertainty using Polynomial Chaos and adjoint equations.*

The non-intrusive Polynomial Chaos (PC) and adjoint equations are considered and their performance compared for estimation of uncertainty of a valuable functional subject to large errors of the input data. Random variables providing maximum impact on the result (leading values) may be found using gradient information that allows reduction of the problem dimension. The Hermite polynomial expansion coefficients are determined for the leading values. The gradient may be also used for calculation of PC coefficients thus enabling further acceleration of the computations. (Received September 22, 2009)

# 94 ► *Information and communication, circuits*

1056-94-145 **Brian Allen*** (ball1190@messiah.edu), Department of Mathematical Sciences, One College Avenue, Box 3041, Messiah College, Grantham, PA 17027, and **Kristen Bretney** (kbretne1@lion.lmu.edu), Department of Mathematics, Loyola Marymount University, One LMU Drive, Suite 2700, Los Angeles, CA 90245. *Analyzing Hyperspectral Images.*

Our research investigated the underlying geometry and performance of various statistical target detection algorithms for hyperspectral imagery with the goal of understanding and utilizing this information to create new target detection algorithms. We will present the various algorithms that we developed along with their results and explain the underlying mathematics involved in these approaches. Our talk will also include an introduction to the physics of hyperspectral imagery for those not familiar with the subject.

Tests of our algorithms are conducted using imagery and targets freely available at http://dirsapps.cis.rit.edu/blindtest/. The imagery was acquired over Cooke City, Montana, a small town near Yellowstone Park, using the HyMap V/NIR/SWIR sensor with 126 spectral bands. (Received August 01, 2009)

1056-94-537 **Tingyao Xiong*** (xiongtin@msu.edu), Math Department of Mathematics, Michigan State University, East Lansing, MI 48823, and **Hall I. Jonathan**. *Construction of Even Length Binary Sequences with High Asymptotic Merit Factor.* Preliminary report.

The known binary sequences having the asymptotic merit factor $\geq 6$ are the modifications to the prime character sequences. In this paper, we show that at $N = pq$, there are many modifications other than the modified Jacobi sequences proposed by Jensen and Hohøldt in 1991. Furthermore, we will give new modifications to the character sequences of length $N = p_1 p_2 \dots p_r$, where $p_i$'s are distinct odd primes. Based on these new modifications, we can construct a binary sequence of length $2N$ so that such families of sequences have asymptotic merit factor 6.0 without cyclic shifting on the base sequences. (Received September 11, 2009)

1056-94-843 **Akram Aldroubi*** (akram.aldroubi@vanderbilt.edu), Dept. of Mathematics, SC1520, Vanderbilt University, Nashville, TN 37240, and **Haichao Wang**. *Compressed sensing via information theoretic methods.*

By considering an $s$-sparse signal $x \sim (X, P)$ to be an instance of vector random variable $X = (X_1, \ldots, X_n)^t$ We determine a sequence of binary sampling vectors for characterizing the signal $x$ and completely determining it from the samples. Unlike the standard approaches, ours is adaptive and is inspired by ideas from the theory of Huffman codes. The method seeks to minimize the number of steps needed for the sampling and reconstruction of any sparse vector $x \sim (X, P)$. We prove that the expected total cost (number of measurements and reconstruction combined) that we need for an $s$-sparse vector in $\mathbb{R}^n$ is no more than $s \log n + 2s$. (Received September 17, 2009)

1056-94-1122 **Lei Hu*** (hu@is.ac.cn), 19A, Yuquan Road, Beijing, 100049, Peoples Rep of China. *Analysis of A Multivariate Internal Perturbation Scheme.*

We present a differential analysis to a middle-field type multivariate internal perturbation scheme. The main point is to reduce the attack against the scheme to an attack on its perturbation-free variant using the property of differentials, and the latter scheme can be totally cracked by linearization equations. This is a joint work with Weiwei Cao. (Received September 21, 2009)

1056-94-1137 **Nikolaos Dimitrios Atreas*** (natreas@csd.auth.gr), Thessaloniki, Greece. *Non-uniform sampling expansions and local reconstruction on subspaces of $L_2(R)$.*

Given a regular function whose Fourier transform has no real zeros and a set of measurements $L_n(f)$ on a $\delta$-separated sampling set ($\delta > 0$), we determine a closed subspace of $L_2(R)$ whose elements are uniquely reconstructed by means of the set $L_n(f)$. We show that the corresponding non-uniform average sampling reconstruction formula for functions in this space exhibits local properties and we present a local reconstruction formula suitable for practical applications. (Received September 21, 2009)

1056-94-1550 **Gong Guang*** (ggong@uwaterloo.ca), Department of Electrical and Computer Eng., University of Waterloo, Waterloo, Ontario N2L 3G1, and **Zilong Wang**. *Polyphase Sequence Families with Low Correlation from the Bounds of Character Sums.* Preliminary report.

There are three classes of polyphase sequence families with low correlation constructed from characters and their correlation functions are upper bounded by directly applying the known bounds of character sums. The first class is constructed using additive characters of finite field $GF(q)$ and the examples include Chu (or Alltop) sequences, and $m$-sequences. The second class is from multiplicative characters of $GF(q)$, for example, power residue and Sidelnikov sequences are those constructions. The third class is from the combination of additive and multiplicative characters, such as the sequences from the Weil representation. In this talk, those constructions as well as the sequence families constructed from the shift and addition of those sequences will be revisited and some new constructions will be given. (Received September 22, 2009)

1056-94-1566 **Yesem Kurt-Peker*** (ykurt@randolphcollege.edu), Randolph College, 2500 Rivermont Ave., Lynchburg, VA 24503. *A Signature Scheme over Non-commutative Groups Secure Against Existential Forgery.* Preliminary report.

We shall introduce a new non-deterministic signature scheme which, under certain assumptions on the hash function used, is secure against existential forgery with adaptive chosen-message attacks when non-malleability is not part of the security requirements; that is producing a second signature to an already queried message does not count as forgery. Different from most signature schemes in use today, the new scheme is designed to work in non-commutative structures. The security of the scheme lies in the difficulty of the decomposition problem in the underlying group. For a concrete example we employ the group of matrices with entries from a finite field and discuss the complexity of operations involved. In the signing process, a user has to do some inversions and also choose elements from the centralizer of a given element. These are the costliest operations in the overall signature scheme. Verification requires 13 multiplications in the group, which, when considered over matrices is a fast operation. Solving the decomposition problem in the case of matrices amounts to solving multivariate polynomial equations which is known to be hard in general. (Received September 22, 2009)

1056-94-1602 **Gianluca Vinti*** (mategian@unipg.it), Dipartimento di Matematica e Informatica, University of Perugia, Via Vanvitelli, 1-06123 PERUGIA, ITALY, 06123 Perugia,Italy, Italy. *Approximation Theory in Signal and Image Processing. Applications to Endovascular Surgery.*

In the last century, Whittaker, Kotelnikov and Shannon stated the celebrated WKS-sampling theorem: let $f \in L^2(\mathbb{R})$ be a function with the support of its Fourier transform $\hat{f}$ contained in an interval $[-\pi w, \pi w]$, for $w > 0$,;then $f$ can be completely reconstructed on the whole real time-axis from its samples values by means of the interpolation series:

$$f(t) = \sum_{k=-\infty}^{+\infty} f(\frac{k}{w}) sinc[\pi(wt-k)],\ t \in \mathbb{R}.$$

Several contributions have been given in order to weaken the band-limitation, but the most important contribution,based on an approximation theory's approach, has been given by P.L.Butzer and his school at Aachen considering a family of discrete operators, called "generalized sampling series" of the form

$$(S_w^{\varphi} f)(t) := \sum_{k=-\infty}^{\infty} f(\frac{k}{w})\ \varphi(wt-k),\ t \in \mathbb{R},\ k \in Z,\ w > 0$$

where $\varphi$ is a continuous function with compact support on $\mathbb{R}$.
For the above operators, behind pointwise and uniform convergence results for continuous signals, we will discuss the approach in $L^p-$setting, which allow to treat signals not necessarily continuous nor of finite energy. In the last part of this talk, some applications to image analysis will be discussed. (Received September 22, 2009)

1056-94-1688 **Anant Sahai*** (sahai@eecs.berkeley.edu), 267 Cory Hall #1770, University of California, Berkeley, CA 94720-1770, and **Kristen Ann Woyach**. *Desired properties of identity codes.* Preliminary report.

Wireless has inspired many problems in the construction of sequences and codes. Recently, the prospect of "cognitive radio" has emerged — systems that can adaptively change their own characteristics based on the local environment. This has been metaphorically compared to the shift from single-track railroads to multi-lane highways where diverse users can share the road responsibly. A new need looms for the wireless equivalent of license plates: codes that can appropriately identify users so that mechanisms can be deployed to enforce good behaviour.

These codes enable radios to share resources, but the way this sharing occurs is different from traditional spread-spectrum approaches. So despite some similarities, what is needed is different from the spreading sequences used for CDMA. A careful look at the interaction of such codes with potential enforcement mechanisms also reveals that their desirable properties resemble Ahslwede's aptly-named "Identification Codes" more closely than they do traditional error-correcting codes. This talk will explain the desired properties as well as present preliminary results. Random-coding constructions tell us that good codes must exist, but to be useful, explicit algebraic or possibly graph-based constructions are needed. (Received September 22, 2009)

1056-94-1747 **Nigel Boston*** (boston@math.wisc.edu), Department of Mathematics, University of Wisconsin, Madison, WI 53706. *Algebra and Multi-Camera Networks.*

Multi-camera networks are a rapidly developing area of research with applications to security, smart homes, and environmental monitoring. Their study combines computer vision, sensor networks, and cryptography. We will indicate how advanced algebra can aid with all three of these tasks. (Received September 22, 2009)

1056-94-1840 **Mahmoud H Annaby*** (mannaby@qu.edu.qa), Dept Mathematics, Satatistics & Physics, Qatar University, Doha, 2713, Qatar, and **Hassan A Hassan** and **Omar H El-Haddad**. *A Perturbed Whittaker-Kotel'nikov-Shannon Sampling theorem.*

The sampling theorem of Whittaker (1915), Kotel'nikov (1933) and Shannon (1949) gives cardinal series representations for finite $L^2-$Fourier transforms at equidistant sampling points. Here we investigate the situation when the Fourier transform is replaced by a perturbed one. Thus the kernel of the transform will be of the type $\exp(-ixt) + \varepsilon(x,t)$, instead of $\exp(-ixt)$ in the unperturbed case. The perturbed kernel arises from first order eigenvalue problems with rank one perturbations. (Received September 22, 2009)

# 97 ► Mathematics education

1056-97-13 **Charles Adam Feldhaus***, 4048 Alwood Ln, Groveport, OH 43125. *What are they thinking? Examining the mathematical disposition of preservice elementary teachers.*

With an ever-increasing emphasis on mathematics education in the early grades, it becomes important to ask what elementary school teachers think of mathematics. The National Research Council (2000) has established a link between students' mathematical proficiency and their disposition toward mathematics, and Ma (1999) links the teachers' mathematical disposition to the mathematical disposition of their students. This paper will examine the mathematical disposition of four preservice elementary teachers and look at some events in the preservice teachers past that were instrumental in forming their present mathematical disposition. (Received April 27, 2009)

1056-97-209 **A. N. Meremikwu*** (annemeremiku@yahoo.com), Block 15 Plot 5 Road 2 FHE, GPO Box 1211, Calabar, CRS 540001, Nigeria. *Why do children in public and rural primary schools perform worse in mathematics: unresolved questions on equitable access to early childhood education?*

Pupils drawn from public, private, urban, rural primary schools in Calabar South-eastern Nigeria were studied Methods: Study design was Quasi-experimental with a 2x2x3x2 factorial design. Main Results: Pupils in private schools performed better than their public school counterparts. Also pupils in urban residential areas performed better than their rural areas. A post hoc analysis showed that the adjusted mean achievement of pupils in private urban schools ( =68.284) is significantly greater than that of pupils in public urban schools ( = 63.912), public semi-urban schools ( = 64.363) and public rural schools ( = 64.719). Pupils in private rural schools had significantly greater adjusted mean achievement score ( =68.0) than those in public urban schools ( = 63.912), public semi-urban ( = 64.363) and public rural ( = 64.719) schools ($p< 0.05$, $t= 1.645$, MSE = 56.839). Conclusions: Disparity in mathematics achievement between children in low-income settings demonstrates inequity in access to early childhood education. (Received August 15, 2009)

1056-97-305 **Jacek Fabrykowski*** (jfabrykowski@ysu.edu), One University Plaza, Youngstown, OH 44555. *Local Research Experience for Undergraduates YSU in the summer of 2008.* Preliminary report.

In the academic year 2007-2008 Youngstown State University had an unusually large number of excellent junior mathematics majors who were interested in doing graduate work. They all had high gradepoint averages in our Honors program, were completing at least a full year of analysis and algebra, in addition to a variety of other courses such as complex, numerical analysis, and number theory. In addition, they had given talks on small research projects locally, regionally, and at MathFest, and some of them had been national award winners. All applied to a variety of REUs for the summer of 2008 but none of the males were accepted to any of the programs.

Because YSU felt it was essential that these students have research experience to compete effectively with REU students when applied for graduate programs, we ran our own REU program in number theory for three of these students. I will discuss how this progam was run, administered, paid for, describe the outcomes of program. I will then give some suggestions for other instiutions who might want to run a program of this type. (Received August 27, 2009)

1056-97-386 **Peter R Turner*** (pturner@clarkson.edu), Clarkson University, School of Arts & Sciences, 8 Clarkson Avenue, Potsdam, NY 13699-5800. *Applied Mathematics for High School Outreach.*

Contests can be a valuable motivator for introducing middle and high school students to applied mathematics. This talk will introduce some of the competitions that are available. Opportunities for both professional development and for student-based activities in applied mathematics will be presented. The talk will also provide a brief introduciton to the remainder of the minisymposium. (Received September 03, 2009)

1056-97-465 **Richard Millman*** (richard.millman@ceismc.gatech.edu), CEISMC, Ga Tech, 760 Spring St. NW, Atlanta, GA 303081028. *Examples of a Mathematical Habit of the Mind and its effect on Students.*

The approach of the mathematical habit of the mind (MHM) is one of the recommendations for future teachers of The Mathematical Education of Teachers (Conference Board of the Mathematical Sciences (2001)). It is used in some texts for future teachers and also as a way to encourage students to go into mathematics. We will look at a few examples from K-12 and undergraduate mathematics as a way to give insights into the nature of MHM. Giving problems that require significant thought (but not advanced methods) to our better students has them realize the attractive subtlety of the subject. For example, showing children that the product of even integers is even is easy and can lead, via MHM, to members of a class in middle school realizing that there is more—the product is divisible by 4. The (false) statement "If n = bc and p is an integer which divides n, then p divides either b or c" has sufficient subtlety that it provides a useful classroom discussion for preservice teachers. The need for a basis which is not i, j, k will be demonstrated using the differential geometry of curves and surfaces and this conversation leads to insights into the mixed geometric and analytic nature of results and techniques. (Received September 08, 2009)

1056-97-606 **Daniel J Teague*** (teague@ncssm.edu), NCSSM, 1219 Broad Street, Durham, NC 27705. *Probability and Determinism at the Battle of Trafalgar.*

The classical Lanchester models for the Battle of Trafalgar (dA/dt = -bB and dB/dt = -aA) generate both student interest and insight into this historical battle. But, with given initial conditions and parameter values, the same side always wins.

If we use a queuing model approach (if you are in state AB now, then you must have been in (A+1)B or A(B+1) or (A+1)(B+1) or AB in the time interval before), we can create a probabilistic model for the battle over time. In the probabilistic model, we have the much more satisfying prospect of predicting how likely one side is to prevail, and what the most likely end stage of the battle will be. (Received September 14, 2009)

1056-97-702 **Nicola D. Edwards-Omolewa*** (nedwardsomolewa@desu.edu), Delaware State University, Department of Mathematical Sciences, 1200 N. DuPont Highway, Dover, DE 19709. *Third Graders' Strategies and Preferences for Solving Arithmetic Problems: A Gender Difference Study.*

The strategies elementary school children use to solve multi-digit addition and subtraction story problems that require regrouping are investigated in two studies. Study 1 replicates the Fennema et al. (1998) study by re-examining existing Hiebert & Wearne (1992, 1993) data on 72 children's addition and subtraction solution strategies. Study 2 is an extension study with new data from individual interviews on 70 third-grade children's multi-digit addition and subtraction problem solving strategies that require regrouping. It extends the Fennema et al. (1998) study by identifying children's strategy preferences and the reasons they provide for those preferences. This presentation will focus on Study 2 where gender differences in strategy use were not as strong as those reported by Fennema et al. (1998). Boys and girls preference reasons reveal different understandings for what it means to learn mathematics. Results support the idea that differences may influence later gender differences in problem solving performance that begin in middle school and continue throughout high school. (Received September 16, 2009)

1056-97-840 **Rachel Levy***, 301 Platt Blvd, Claremont, CA 91711. *Soap and Slope: Exploration of gradients through hands-on experiments with surfactants (outreach module for grades 7-12).*

The purpose of this session is to share outreach activities used successfully with middle and high school students. I will demonstrate (and you can try!) activities to introduce the concept of slope (gradient) through activities with simple and inexpensive materials. We will also discuss how to tie outreach activities to discussions with students about research in applied mathematics. (Received September 17, 2009)

1056-97-846 **Maria Zack*** (mzack@pointloma.edu), Point Loma Nazarene University, Mathematical, Information & Computer Sciences, 3900 Lomaland Drive, San Diego, CA 92106, and **Greg Crow** (gcrow@pointloma.edu), Point Loma Nazarene University, Mathematical, Information & Computer Sciences, 3900 Lomaland Drive, San Diego, CA 92106. *Undergraduate Research and Service Learning Projects Developed from Institutional Research Questions.*

For ten years, Point Loma Nazarene University (PLNU) has had a program in the Department of Mathematical, Information and Computer Sciences that incorporates the university's institutional research needs into senior honors research and service learning projects conducted by upper classmen. Students work under the supervision of the faculty members in the department who are engaged in institutional research and all students are expected to take coursework in statistics before undertaking any of these projects. The projects have included: using Arcview GIS to develop a graphical model to study the effectiveness of the diversity recruitment strategy of the PLNU Admissions Office; developing a model for student retention; collating and analyzing six years of the university's HERI survey data with a focus on learning outcomes; and developing a model for identifying "academically at risk students" early in their freshman year. This endeavor has yielded some helpful institutional information at a very low cost to the university while helping the students to develop mathematical and professional skills while working on "real world problems" for customers and has lead to a number of students pursuing graduate studies and careers in quantitative analysis. (Received September 18, 2009)

1056-97-871 **Kathleen R Fowler*** (kfowler@clarkson.edu), 8 Clarkson Ave, Box 5815, Department of Mathematics, Potsdam, NY 13699, and **Peter Turner**, **David Wick** and **Michael Ramsdell**. *K-12 Outreach with Integrated Math and Physics for Roller Coaster Design.*

We present an overview of learning experiences focused on roller coaster design that integrate mathematics and physics for grades 7-12. This workshop will include some hands-on design aspects and ideas that can easily be implemented in the classroom or as part of an after-school enrichment program. These projects are motivated in part by a NYSED funded school year program targeted at middle and high school students that culminates at a week long, roller coaster camp each summer and the use of a programmable Maxflight 2002 Virtual Reality Roller Coaster that resides on our campus and a visit to Six Flags to collect data on real roller coasters. (Received September 18, 2009)

1056-97-1045 **Michael Tabor*** (tabor@math.arizona.edu), Program in Applied Mathematics, University of Arizona, Tucson, AZ 85721-0089. *The Applied Mathematics Laboratory: translating what you see into what you do.*

Many of the most important advances in mathematics have been motivated by the need to explain fundamental phenomena, such as the motion of planets and fluids; or to quantify and predict the complex structures that develop in physical and natural systems. To fully appreciate the modeling, quantification, and explanation of such important and varied processes much is to be gained by exposure to the relevant observations and experiments in conjunction with the associated mathematical analysis. Direct, hands-on, experimentation can help develop intuition about complex processes and how to model them. The goal of the Applied Mathematics Laboratory is to provide students with an innovative approach to mathematical modeling through the use of laboratory experiments in ways that not only teach good mathematics but also helps develop an appreciation of scientific methodologies and critical professional skills. The Applied Mathematics Laboratory at the University of Arizona is used for a required course for all first year graduate students, advanced graduate courses in mathematical modeling, research, and outreach. The Laboratory was started with a grant from the NSF Division of Mathematical Sciences in 1994. (Received September 20, 2009)

1056-97-1520 **Hyman Bass*** (hybass@umich.edu), 4124 School of Education, University of Michigan, Ann Arbor, MI 48109, and **Deborah Loewenberg Ball** (dball@umich.edu), 1110 School of Education, University of Michigan, Ann Arbor, MI 48109. *What can Mathematicians Contribute to Research in Education?*

This paper examines the nature of the core problems in research in education and analyzes the unique contributions that mathematicians can bring to the posing, framing, analysis, and solutions to those problems. Using perspectives drawn from Andy Magid's work together with what we have learned from our own efforts to bridge different disciplinary training and professional experience, we propose five fundamental contributions that mathematics – and mathematicians – can make to research in education. We also consider the challenges posed for mathematicians who aspire to engage with the world of education research and discuss implications for their preparation and engagement in ways that make possible the unique contributions that they can make to solving important problems in education. (Received September 22, 2009)

1056-97-1889 **David O Lomen*** (lomen@math.arizona.edu), Math Dept, University of Arizona, Building # 89, Tucson, AZ 85721. *Use of ConcepTests and Voting in Upper Division Math Courses.*

Using questions as a catalyst for classroom discussion and voting has been demonstrated in many lower division mathematics courses. Examples incude precalculus, calculus, linear algebra, and differential equations. At the University of Arizona, we are developing questions pertaining to complex variables, Fourier series, LaPlace transforms and partial differential equations. Examples will be given along with student responses. (Received September 22, 2009)

1056-97-1914 **Carole Basile**, **Steve Culpepper** and **Steven Di Lisio*** (steve.dilisio@gmail.com), 1920 Denver West Dr. Apt. 811, Golden, CO 80401, and **Adam Ruff** and **Diana White**. *Social Network Surveys in Math and Science Education.*

Social network analysis is a relatively new and powerful tool which can be used to gain information about many types of personal interaction. In this talk, we discuss our use of social network analysis to study the advice networks of math and science teachers who participated in the Rocky Mountain Middle School Math and Science Partnership. Analyzing the data requires mathematical concepts from graph theory and statistics. We will provide an overview of the basic concepts needed, assuming no prior knowledge of the area, as well as describe our findings. (Received September 22, 2009)

1056-97-2070 **Elsa Medina*** (emedina@calpoly.edu), Cal Poly State University, San Luis Obispo, CA 93407. *Mathematics majors' believes about mathematics after taking a methods of proof class and professors' believes about the effectiveness of such a class.*

Many universities offer a methods of proof class and make it a requirement for undergraduate mathematics majors. Such a class may be the first formal introduction to proofs for many mathematics majors (other than the geometry proofs students may see in high school) and many of them tend to struggle in this class. A pre- and post survey was given to mathematics majors in four classes to investigate whether their believes about mathematics, their ability to do mathematics, and their confidence of having chosen the right field of study changed after a methods of proof class. The results of the survey will be presented as well as preliminary results of professors' believes about the effectiveness of a methods of proof class for mathematics majors. (Received September 23, 2009)

# 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.

# Invited Addresses, SIGMAA Guest Lectures, and Presentations by Teaching Award Winners

1056-A0-2 **Glen Van Brummelen***, Quest University, 3200 University Blvd., Squamish, BC. *Reasonable effectiveness: Trigonometry, ancient astronomy, and the birth of applied mathematics.*

Trigonometry, one of the oldest of the mathematical sciences, was born in ancient Greece from the need to predict the positions of the heavenly bodies. The arrival of an efficient place value number system from Babylon allowed geometry to become quantitative, changing the astronomical game entirely. Astronomers and geographers in Greece, and later in India and medieval Islam, now had unprecedented powers to describe mathematically the world they observed around them. Not least among trigonometry.s accomplishments was its role in one of the most successful predictive theories in the history of science: Ptolemy's epicyclic model of planetary motion. The fact that this model was completely wrong, yet its mathematics proved fundamental to the growth of science for at least two millennia, leads to some interesting speculations on Wigner's observation of the .unreasonable effectiveness of mathematics in the natural sciences. (Received March 24, 2009)

1056-A0-4 **Lenore Blum***, Carnegie MellonUniversity, Department of Mathematics, Pittsburgh, PA 15213. *The real computation controversy: Is it real?.*

There are two major "competing" approaches to modeling computation over the reals, the algebraic approach and the bit model approach. I would argue that each abstraction provides useful insights. Moreover with regard to computational complexity, the two approaches are naturally linked via the condition of a problem instance, as introduced by Turing in 1948. Much work has been done durin g the past decase pursuing this direction. (Received March 25, 2009)

1056-A0-5 **Dusa McDuff***, Barnard College, Columbia University, New York, NY 10027. *Symplectic embeddings and continued fractions.*

It has been known since the mid eighties that embedding problems lie at the heart of symplectic geometry.This talk will start with a general discussion of such problems, mentioning various recent generalizations of Gromov's nonsqueezing theorem and of the symplectic capacities introduced by Ekeland and Hofer.It will end with a description of recent joint work with Schlenk about embedding four-dimensional ellipsoids. This turns out to have interesting connections with the properties of continued fractions. (Received March 25, 2009)

1056-A0-11 **Sue Whitesides*** (sue@uvic.ca), Department of Computer Science, PO Box 3055 STN CSC, Victoria, BC V8W 3P6, Canada. *Motion Planning and Graph Layout: at the Crossroads of Geometry, Discrete Mathematics, and Algorithm Design.* Preliminary report.

To visualize a graph, or to realize the connectivities it represents as a circuit of wires or a network of pipes or highways, one must assign its vertices and edges to concrete locations; that is, one must "draw" the graph. Alternatively, abstract graphs can be realized by a variety of geometric relationships such as visibility, contact, or proximity relations.

When a graph represents a linkage of rods hinged together at their endpoints, its movement properties can exhibit a range of intriguing behaviors and challenging questions, even for a graph as simple as a chain of links.

In this talk, we take a look at problems at the intersection of geometry, discrete mathematics, and algorithm design, focusing on layout and path planning problems. (Received September 21, 2009)

1056-A0-15 **David T. Kung***, Saint Mary's College of Maryland, Department of Mathematics, St. Mary's City, MD. *How math made modern music ~~mad~~ Irrational!*

The scale used by 20th century classical musicians is strikingly different from that used in Bach's time. In fact, over the past 500 years, a wide variety of scales have permeated Western music. Amazingly, none of them was "in tune"! In fact, in some sense, no piano is **ever** in tune.

The reason for this is purely mathematical.

Starting with a single vibrating string, we'll use some physics and some advanced mathematics to make sense of the various sounds a violin can make. Add to the mix a little music theory and some basic arithmetic, and we'll be able to construct several different scales and see what's "wrong" with each one. Finally, by constructing the modern scale, we'll be able to answer the question posed in the title.

Throughout the talk, these concepts will be illuminated with excerpts played on the violin, including passages from Bach, Mendelssohn, and a few more modern composers. (Received May 05, 2009)

1056-A0-68 **Reviel Netz***, Stanford University. *The Archimedes Palimpsest and its infinite possibilities.*

What we know of Archimedes comes from Medieval manuscripts. By far the most important is a palimpsest - a medieval copy erased and overwritten with a prayer book. Transcribing the Archimedes Palimpsest, we have gained in the last decade new insight into his mathematics. The talk will present some highlights of those new insights, concentrating on this question: how did Archimedes think about infinity? (Received July 21, 2009)

1056-A0-623 **Michael Dorff*** (mdorff@math.byu.edu), Department of Mathematics, Brigham Young University, Provo, UT 84602. *What we are doing at BYU to increase the number of students taking mathematics courses and becoming math majors.*

There are many aspects of my teaching that I could share: exciting activities that I do in my classes; effective ways to mentor undergraduates in research; or even the successful results of CURM, the Center for Undergraduate Research in Mathematics. However, in a recent survey of MAA members, 73% of the respondents listed “attracting students to the major” as a big issue that the MAA needs to direct more attention to. And so I think that it will be beneficial to more people if I discuss some principles and specific activities that we have used in the Mathematics Department at Brigham Young University to increase the number of students taking mathematics courses and becoming math majors. Some principles include creating a culture of “Math is cool!”, exposing students to careers and opportunities available to those who study mathematics, and being proactive in your efforts. Along the way, I will talk about some specific activities such as our “Careers in Mathematics” seminar, a freshman/sophomore class titled “Intro to being a math major,” the creation of a student advisory council that suggests ways to improve the department, a big screen HDTV display with a PowerPoint presentation about mathematics, a set of 5 BYU math t-shirts, and the “When Will I Use Math” website. (Received September 14, 2009)

1056-A0-767 **Allan J. Rossman*** (arossman@calpoly.edu), Dept of Statistics, Cal Poly, San Luis Obispo, CA 93407. *Ask Good Questions.*

Legend has it that when asked how to be a successful singer, Frank Sinatra replied: Sing good songs. My advice for successful teaching can be summarized in a similarly succinct manner: Ask good questions. What do I mean by this? (Hey, there’s a good question!) 1) Ask good questions that lead students to develop their own understanding of key concepts. 2) Ask good assessment questions that promote learning and focus attention on the skills you value. 3) Ask good questions that capture students’ interest, motivate them to study, and convince them of the material’s value. 4) Inspire students to ask good questions themselves, not only about the course but also about issues of interest to them in the ”real world” that can be addressed using the intellectual tools they are learning. Oh, and what makes a question ”good”? (Another excellent question; thanks for asking!) Good questions make students think (duh!), address important ideas, build on students’ knowledge or confront their misconceptions, challenge students without overwhelming them, motivate students to answer them, and lead students to ask their own questions. In this talk I aim to convince you of the importance of my thesis (in case you missed it: Ask Good Questions!), providing many examples from my teaching of statistics. (Received September 19, 2009)

1056-A0-1220 **Charles Chihara*** (charles1@berkeley.edu). *What is Philosophy of Mathematics? A Case Study of Fictionalism.*

This talk explains what philosophy of mathematics is in terms of its goals. The talk then provides an overall assessment of a particular account of mathematics called ”Fictionalism” from the perspective of the general account of philosophy of mathematics provided earlier in the talk. (Received September 21, 2009)

1056-A0-1339 **Curtis D. Bennett*** (cbennett@lmu.edu), 1 LMU Drive, Suite 2700, Los Angeles, CA 90045. *Lessons learned in the teaching and learning of mathematics.*

In this talk, we will briefly discuss lessons I have learned from my own teaching and learning of mathematics including: listen to others; interesting mathematics lies in the most unlikely of places; motivate; and how to fight pedagogical amnesia. (Received September 21, 2009)

1056-A0-1541 **Barry A Cipra*** (bcipra@rconnect.com), 305 Oxford St., Northfield, MN 55057. *From Netflix to Gerrymanders: A Sample of BIG Applications of Mathematics.*

The speaker has been privileged to report on developments in the mathematical sciences over the last two decades for publications such as *Science* and *SIAM News*. Many of the most fascinating stories have been about applications of mathematics to real-world problems. I will describe a few examples highlighting the unreasonable effectiveness of mathematics in addressing important problems in business, industry, and government. I will also comment generally on what makes for a "good" math story. Among the tricks of the math-reporting trade: Sex sells. (Received September 22, 2009)

# Environmental Modeling

1056-BA-1672 **Courtney Brown***, polscb@emory.edu, Atlanta, GA. *Warming, Non-linearity & Civilization's Decline.*

While many models of the environment address the subject of global warming, they tend to account for physical factors, such as atmospheric carbon dioxide concentrations. Yet these models have largely ignored the consequences of feedback resulting from the collateral damage done by global warming to governmental capability. This essay directly addresses this void in the literature by showing how governmental and civilization capacities in the context of appreciable global warming can be nonlinearly affected by dynamic system limits that are themselves dependent on the level of environmental damage resulting from global warming. Under plausible conditions, nonlinear feedbacks can encourage a simultaneous degradation and possible collapse of both civilization economic capacity and governmental response capacity, resulting in potentially dire global consequences. Recognizing these potentials now enables policy makers to account for such nonlinear complexities in a more complete framing of the global warming scenario that is currently confronting world leaders. (Received September 22, 2009)

1056-BA-1678 **Jim M. Cushing*** (cushing@math.arizona.edu). *Evolution of Competitive Co-existence.*

A long-held dogma of ecology is competitive exclusion, the assumption that only one species can survive in a specific ecological niche. A classic series of experiments with flour beetles in the 1960's confirmed this belief in every case but one. It was difficult to ignore an experiment in which two species of beetles coexisted in a container of flour for 30 generations. This apparent anomaly can be explained by taking into account small, evolutionary changes in one of the beetles. Population dynamics models of competition are inadequate to explain these changes but modifications introduced using evolutionary game theory (EGT) yield a model that is in agreement with experimental data. EGT provides a methodology for extending a population dynamic model so as to account for the evolution of phenotypic traits (with heritable components) subject to natural selection. An EGT version of a classic competition model will be used to investigate how evolution can change the outcome of the interaction. Specifically, we will use this approach to explain how a two-species system can evolve from competitive exclusion to coexistence, and also how it can evolve from exclusion of one species to exclusion of the other. (Received September 22, 2009)

1056-BA-1714 **Roland H. Lamberson*** (rhl1@humboldt.edu). *Endangered Salmon in the Columbia River Basin.*

At the time of Lewis and Clark, about 15 million salmon were returning to spawn in the Columbia Basin each year. Current returns are about one million with most of those resulting from artificial hatchery production. Of the more that 200 salmon stocks existent in the 19th century, it is thought that more than 140 are now extinct or at risk of extinction and only nine are considered healthy. Each year over 200 million salmon and steel head juveniles are released from hatcheries. These hatchery fish compete with the endangered wild salmon and steel head populations. In this presentation, I will give an overview of the COMPASS Model, the major model used to study salmon dynamics in the Columbia River System and then look at a more specialized model to examine the competition between hatchery fish and wild fish and use it to demonstrate some of the problems in recovering the wild populations. (Received September 22, 2009)

1056-BA-2121 **Louis J. Gross*** (gross@tiem.utk.edu). *Environmental Modeling & Big Projects: Lessons from Everglades Restoration Planning.*

As human-dominated systems spread across our planet, we need to evaluate how human modifications to natural systems impact the services provided by ecosystems. While inherently a global issue, much of our planning occurs at a regional level. Mathematical and computational models play a key role in regional planning – it is impractical to carry out controlled experiments at these scales. Models can assess alternative scenarios, incorporate the trade-offs important to stakeholders with differing criteria for the objectives of management, and consider the impacts of uncertainty of future conditions. One of the largest attempts to date to evaluate alternative management plans at regional extent has been the massive project associated with the restoration of the Everglades of South Florida. To provide a common scientific framework to assess the impacts of alternative plans on the biotic components of the natural systems, we developed a multi-model (ATLSS - Across Trophic Level System Simulation) consisting of many linked-models using different mathematical approaches & coordinated through a common set of tools. I'll describe how we developed ATLSS, how the differing models address biological questions for various ecosystem components, and lessons learned from this long-term project. (Received September 23, 2009)

# Gems of Number Theory

1056-BB-510 **William A Stein*** (wstein@gmail.com), University of Washington, Department of Mathematics, Box 354350, Seattle, WA 98195-4350. *Sage: Creating a Viable Free Open Source Alternative to Magma, Maple, and Mathematica for Number Theory.*

I initiated the Sage mathematical software project (http://sagemath.org) in 2005 to provide a powerful free open source web-friendly software package for computations in number theory. It has since grown to cover a wide range of other areas with contributions from over 200 people. In this talk, I will give a spirited introduction to Sage via a couple of well chosen computational demonstrations. (Received September 10, 2009)

1056-BB-530 **Bruce C Berndt*** (berndt@illinois.edu), Dept. of Mathematics, Univ. of Illinois, 1409 W. Green St., Urbana, IL 61801. *Ramanujan Reaches His Hand from His Grave to Snatch Your Theorems From You.*

Because many of Ramanujan's theorems were hidden in his (earlier) notebooks and lost notebook for many years, other mathematicians discovered some of these results without realizing that their discoveries were originally due to Ramanujan. We discuss several such examples. (Received September 11, 2009)

1056-BB-607 **Alice Silverberg***, Mathematics Department, UC Irvine, Irvine, CA 92697-3875. *Counting points on elliptic curves, from Gauss to the present.*

In his Disquisitiones Arithmeticae, Gauss published a simple formula for the number of solutions mod $p$ to $x^3 - y^3 = 1$. In his last diary entry, Gauss gave a similar result for the number of solutions mod $p$ to $x^2 + y^2 + x^2y^2 = 1$. In modern language, these results can be viewed as part of an extensive history of counting points on elliptic curves over finite fields, which now has applications to cryptography. This talk will discuss some of this history. (Received September 14, 2009)

1056-BB-632 **Ira M. Gessel*** (gessel@brandeis.edu), Department of Mathematics, MS 050, Brandeis University, Waltham, MA 02453. *Combinatorial Proofs of Congruences.*

In 1872, Julius Petersen published a frequently rediscovered combinatorial proof of Fermat's theorem $a^p \equiv a \pmod{p}$, where $p$ is a prime: If we color the spokes of a $p$-spoke wheel in $a$ colors, and call two colorings equivalent if one can be rotated into the other, then every equivalence class contains $p$ colorings except for the $a$ equivalence classes consisting of a single monochromatic coloring. Petersen gave a similar proof of Wilson's theorem $(p-1)! \equiv -1 \pmod{p}$, and Lucas's theorem $\binom{ap+b}{cp+d} \equiv \binom{a}{c}\binom{b}{d} \pmod{p}$, where $0 \le b, d < p$ can be proved by the same idea: if a group of order $p$ (or a power of $p$) acts on finite set $S$ then the size of every orbit is either 1 or a multiple of $p$, so $|S|$ is congruent modulo $p$ to the number of fixed points.

I will describe how this approach can be applied to find congruences for Bell numbers, derangement numbers, and other sequences of combinatorial interest. (Received September 15, 2009)

# Mathematics and Education Reform

1056-BC-815 **Andrew G Bennett*** (bennett@math.ksu.edu), Dept. of Mathematics, Cardwell Hall, Kansas State University, Manhattan, KS 66506, and **Rachel B Manspeaker**, **Rekha Natarajan** and **Jennifer Paulhus**. *Studio College Algebra at Kansas State University.*

Over the past several years we have designed, tested, and implemented a new college algebra course at Kansas State University, inspired by the CRAFTY guidelines. The distinguishing feature of this course is a weekly studio where students apply the concepts learned in the lecture sections by working with real world data and modeling techniques. We will give an overview of the course, specifically several of the studios. We also address what was required to implement this course for the large population it serves and discuss its success. (Received September 17, 2009)

1056-BC-826 **Paul J Sally*** (sally@math.uchicago.edu), 5734 S. University Ave, Chicago, IL 60637. *Inquiry Based Learning at Chicago.* Preliminary report.

Who? What? Where? When? Why? To what degree? (Received September 17, 2009)

1056-BC-868 **Bill Haver*** (whaver@vcu.edu), Box 2014, Department of Mathematics, Virginia Commonwealth University, Richmond, VA 23284, and **Aimee Ellington**. *Modeling Based College Algebra at Virginia Commonwealth University.*

The Virginia Commonwealth University mathematics department offered pilot sections of a Modeling College Algebra course beginning in fall 2004, carefully assessed the experiences of students in this and subsequent courses, and continually modified the course to meet the needs of our students and instructional staff. Based on this experience, the department decided to offer, beginning in spring 2008, a Modeling Based College Algebra course to all of the approximately 2000 students who enroll in College Algebra in 65 sections each calendar year. Overall the instructors have been very pleased with the results. The DFW rate was reduced from 38% in traditional classes in 2004-2006 to 22.1% in the modeling sections in fall 2008 and, even though more students completed the modeling course, they were more successful in subsequent courses than students who completed the traditional course. (Received September 18, 2009)

1056-BC-1121 **William Barker*** (barker@bowdoin.edu), Department of Mathematics, Bowdoin College, 8600 College Station, Brunswick, ME 04011. *The Power of Guided Discovery Analysis.* Preliminary report.

Since 1976 the speaker has taught *Introduction to Analysis* over ten times at Bowdoin College using a small group, cooperative, guided discovery format—no lectures. The content is standard: set theory, the real numbers, metric spaces, differentiation, and Riemann integration. But the guided discovery approach brings added vitality and excitement to this standard material. The students—from all levels of preparation and ability—become captivated by the concepts and results, aware of the subtleties, and develop true skill in rigorous mathematical thinking. The course is effective and a pure joy to teach. You too can do this. We'll show you how. (Received September 21, 2009)

1056-BC-1183 **Don Small*** (Donald.Small@usma.edu). *MAA/CRAFTY College Algebra Guidelines.*

The MAA committee Curriculum Renewal Across the First Two Years developed the College Algebra Guidelines for a course emphasizing the use of algebra and functions in problem solving and modeling, providing a foundation in quantitative literacy, and helping meet quantitative needs in, and outside of, academia. Students address problems presented as real world situations by creating and interpreting mathematical models. These guidelines have been endorsed by CUPM, the Committee on the Undergraduate Program in Mathematics. A panel consisting of Don Small, chair; Bill Haver; Erick Hofacker; Irene Hastings; Bernadette Turner; Andy Bennett; and Barbara Edwards will describe the Guidelines. Elsewhere in the program the panelists will describe the impact of courses at their institutions that have been developed and offered in the spirit of the Guidelines. (Received September 21, 2009)

1056-BC-1250 **Michael Starbird*** (starbird@mail.utexas.edu), Department of Mathematics, The University of Texas at Austin, 1 University Station, C1200, Austin, TX 78712. *Guided Discovery: Matters Mathematical and Beyond.* Preliminary report.

Guided discovery methods of instruction are centered on students' proving theorems on their own and presenting their results to their peers. Expected outcomes for students include their developing theorem-proving skills and the ability to tell whether a proof is correct or flawed. But beyond those mathematical skills, this experience frequently involves interesting consequences on students' attitudes concerning self-reliance, independent thinking, and willingness to make mistakes. Those lessons can change students' lives for good. Guided discovery can be an important component of the education of students. (Received September 21, 2009)

1056-BC-1251 **Sten F Odenwald*** (sten.odenwald@nasa.gov), NASA Godard Spaceflight Center, Code 672.1, Greenbelt, MD 20895. *Introducing Students and Teachers to the Connections Between Science and Mathematics using NASA Space Science Discoveries as a Vehicle for Mathematics Education.*

We all know that mathematics is the foundation of all scientific research, and a cornerstone of contemporary STEM education. However, mathematics tends to be overshadowed by the qualitative teaching of general scientific concepts in the 'K-12' classroom, primarily because mathematics is perceived as a difficult topic to most students, especially in elementary and middle-school classrooms. To make matters worse, the selection of applied math problems in most textbooks tends to favor economics or consumer math as popular themes. By high school, students are largely unaware that math is involved in the physical sciences, until they do poorly in their first course in chemistry or physics. What a shock!! The Space Math @ NASA (http://spacemath.gsfc.nasa.gov) was created in 2004 to show how basic math skills are woven into the process of scientific research and discovery. This program offers hundreds of 'one-page' math-oriented problems that focus on a wide range of real-world space science topics. I will present a few examples of math problems that capitalize on resent NASA discoveries, and introduce students to additional examples of how a variety of math skills were employed to create the quantitative information accompanying selected press releases. (Received September 21, 2009)

1056-BC-1266 **Alan D Gould*** (agould@berkeley.edu), Univeresity of California, Lawrence Hall of Science, Berkeley, CA 94720-5200. *Mathematics Concepts Needed in the Global Systems Science Course.*

The Global Systems Science project (GSS; http://lhs.berkeley.edu/gss) created an integrated interdisciplinary course for high school that deals with societal issues that require science for full understanding, e.g. climate change, loss of biodiversity, population growth, ecosystem change and energy use. The mathematics principles that underlie the science are very important elements of the course. Math skills needed include probability, proportions and scale, percentage, exponential growth, logarithmic scales, algebra, geometry, and of course analysis of graphs. For this paper/presentation, we focus in particular on tools for graphing and analyzing CO2 concentration data that is readily available through the Internet, as well as the mathematics required for understanding the concept of "payback time" – how long it takes to recoup up-front costs with energy-saving technologies such as efficient light bulbs and solar electric systems. (Received September 21, 2009)

1056-BC-1314 **Thomas J Pfaff*** (tpfaff@ithaca.edu), Mathematics Department, Ithaca College, Ithaca, NY 14850, and **Ali S Erkan**, **Jason G Hamilton** and **Michael Rogers**. *How Calculus can Participate in Multidisciplinary Sustainability Modules.* Preliminary report.

College education has always had the responsibility to produce individuals who are well on their way to become experts in their field of interest. However, as society faces ever more complex problems that require systems thinking, we also see the growing importance of producing professionals who have the skills to work with people from a diverse set of disciplines. In broad terms, this new educational challenge can be addressed through either an interdisciplinary approach or a multidisciplinary approach. With an interdisciplinary approach participants must become fluent in the participating disciplines so that ideas and concepts from different disciplines are integrated to generate new ways of thinking. Through a multidisciplinary approach, the distinct perspectives and concepts of each discipline can be used to tackle particular portions of a complex problem; fluency in all the participating disciplines, however, is no longer emphasized. A multidisciplinary approach works well with the existing systems we see in today's institutes of higher education. In this talk, we will give an example of a multidisciplinary module centered around the theme of climate change, with an emphasis on the role Calculus I in the module. (Received September 21, 2009)

1056-BC-1346 **Lynn Narasimhan*** (cnarasim@depaul.edu), 990 W. Fullerton Avenue, Chicago, IL 60614, and **Paul Sally**. *The Chicago Algebra Initiative: A Multi-University Collaboration with the Chicago Public Schools.*

In this session, we will describe a seven-year collaborative initiative in Chicago established to increase the number of 8th grades students who have the opportunity to take a rigorous high school algebra course. The presentation will include an overview of the initiative and will focus on the collaborative aspects of the project involving three Chicago universities working in partnership with the Chicago Public Schools. (Received September 21, 2009)

1056-BC-1356 **Michael Starbird*** (starbird@mail.utexas.edu), Department of Mathematics, RLM 8.100, The University of Texas at Austin, 1 University Station C1200, Austin, TX 78712-0257, and **William Barker** (barker@bowdoin.edu), Department of Mathematics, Bowdoin College, 8600 College Station, Brunswick, ME 04011. *Panel Session: Guided Discovery Learning.* Preliminary report.

Courses based on Guided Discovery Learning are highly effective at nurturing creative and independent mathematical thinking in their students. But faculty members not familiar with the method are often unsure about how it works and what their role should be in such a setting. In addition, departments are often unsure about how a Guided Discovery experience could fit into their program. This panel will focus on practical issues of how to learn and effectively implement Guided Discovery methods. (Received September 21, 2009)

1056-BC-1357 **David C Jabon*** (djabon@depaul.edu), 990 W. Fullerton Ave, Rm 4402, Chicago, IL 60614, and **Paul J. Sally, Jr.** (sally@math.uchicago.edu), 5745 University Ave., Chicago, IL 60637. *The Chicago Algebra Initiative: Data and Results.*

This session will summarize evaluation data related to the Chicago Algebra Initiative. We will present results of assessments of professional development component of the program, results of performance assessments of eighth grade student who took part in the program, and preliminary data tracking the high school progress of students

who participated in the program. This data provides evidence of increasing access to high school level algebra to students in Chicago Public Schools. (Received September 21, 2009)

1056-BC-1427 **Bill Jacob*** (jacob@math.ucsb.edu), Department of Mathematics, University of California, Santa Barbara, Santa Barbara, CA 93106, and **Sarah Hough**, **Kyunghee Moon** and **Monica Guzman**. *The Development of Pedagogical Content Knowledge about Early Algebra: A Comparative Study.* Preliminary report.

Findings from an ongoing design research study that explores the development of early pedagogical content knowledge (PCK) in prospective elementary and secondary teachers (UCSB undergraduates) will be presented. An instructional sequence of activities designed to strengthen prospective teacher's own mathematical understanding as well as foster their ability to understand children's mathematics was analyzed. Results indicate that individual and collective mathematical practices and norms that emerge in the two classrooms and the differences between them serve to enhance and constrain prospective teachers developing PCK. The instructional sequence is based on collaborative work with Catherine Fosnot (CCNY) and Maarten Dolk (Freudenthal Institute). (Received September 21, 2009)

1056-BC-1444 **Mary Lou Zeeman*** (mlzeeman@bowdoin.edu), Dept. of Mathematics, Bowdoin College, 8600 College Station, Brunswick, ME 04011. *Climate and Sustainability in the Mathematics Curriculum.* Preliminary report.

The goal of this session is to help empower us to infuse the mathematics curriculum with examples from climate change and sustainability. There are many good reasons for doing this. The motivational power of these subjects is enormous, and can inspire students in mathematics at all levels. Mathematics underlies many of the deep questions facing climate modeling and the development of a sustainable society, and we are in an excellent position to help prepare the next generation of leaders and researchers who will tackle these problems. Similarly, the mathematics classroom is a natural place to contribute to the general climate literacy of society. In this introductory talk I will describe some examples of how climate and sustainability questions are being used, and could be used, at various levels in the mathematics curriculum. (Received September 21, 2009)

1056-BC-1501 **Barbara E. Edwards*** (edwards@math.oregonstate.edu), Oregon State University, Department of Mathematics, 368 Kidder Hall, Corvallis, OR 97331. *Revitalizing Algebra for First-Year College Students: An Attempt to Change Students' Beliefs and Attitudes.*

In 2005 College Algebra (the first 10 weeks of our pre-calculus sequence) was the largest course in terms of enrollment at Oregon State University. However, fewer than 50% of students enrolled in the course passed with an A, B, or C each term. In an attempt to improve student success we have created a new preparatory course; one that is based upon research in mathematics education, involves modeling authentic real-world situations with algebraic functions and employs a student-centered pedagogy. One of our primary goals has been to change students' attitudes, help them attain more confidence and teach them some mathematics along the way. In this talk we will discuss our efforts over the past three and one-half years – the successes, failures and on-going revisions - and share some of our results. (Received September 22, 2009)

1056-BC-1693 **Stephanie R Nichols*** (srnichol@gmail.com), 422 N Kenmore St, Arlington, VA 22201. *A comparison of Inquiry-Based Learning at the Undergraduate and Secondary Levels.* Preliminary report.

Mathematical proof and justification are essential to a strong mathematics education but very often students complete their mathematics studies with limited abilities to construct and validate mathematical proofs. Research and learning theory claim that participation in mathematical discourse provides opportunities for understanding. The use of inquiry-based learning is a way to address both of these issues. Many educational researchers have studied inquiry-based learning at all levels; however elementary classrooms have been the main focus of this type of learning. There are a growing number of educational researchers interested in this type of teaching at higher levels. I will share results of my dissertation research on student-to-student discourse in an inquiry-based transition to proof course, my experiences as a math educator leading workshops with mathematics faculty interested in changing their teaching, and my own experiences incorporating IBL in my high school Euclidean Geometry course. I will discuss the difficulties as well as the successes that I have experienced as a student, a mentor, and a new IBL instructor. (Received September 22, 2009)

1056-BC-1753 **Deborah Hughes Hallett*** (dhh@math.arizona.edu), Department of Mathematics, University of Arizona, Tucson, AZ 85721. *Climate Change: Impact and Opportunities.*

The predictions of climate change are based on mathematics and statistics, yet their impact will be across continents, across societies, and studied by multiple disciplines. Our students will be the ones who must manage the effects of climate change. If effective, their responses will be interdisciplinary. The education they receive can set a powerful example. If it is interdisciplinary, if they see the faculty thinking across boundaries—intellectual, geographic, political—they will be quicker to adapt and to think outside the box themselves. In addition, the desire to understand the world they will live in motivates students to learn the mathematics underpinning climate change predictions. This talk will provide examples of curriculum and of the interdisciplinary windows they can open in the classroom. (Received September 22, 2009)

1056-BC-1761 **Bernadette F. Turner*** (turnerb@lincolnu.edu), Dept. CSTM 820 Chestnut St, Jefferson City, MO 65101, and **Donna Stallings**. *Retention Benefits of Refocused College Algebra.*

Refocused College Algebra is part of an NSF Grant funded to Don Small at West Point Military Academy. The focus of this approach is to combine ideas of statistical analysis with the ordinary algebraic manipulations and analysis of College Algebra in Mathematical Applications. This grant was specifically designed to study the effects of refocusing college algebra on student retention in College Algebra classes for HBCU institutions throughout the United States. During the workshop, criteria were presented for a more cohesive design of curriculum. This design has influenced organization of other classes for reform as well. Thus, syllabus, exams, and homework coincide so that testing and teaching what is stated in goals and objectives is carefully constructed as part of the syllabus. Results of these efforts have assured that both teachers and students are more focused on their related expectations. (Received September 22, 2009)

1056-BC-1772 **Irene M Haskins*** (haskinsi@fc.husson.edu), Irene Haskins, One College Circle, Bangor, ME 04401. *Traversing Bumps Along the Road to a Contemporary College Algebra Curriculum.* Preliminary report.

What happens when you invite the Dean to your contemporary algebra class to listen to the students present poster projects and there's a major disconnect? You're interested in how the students organized and used data on their posters, the students are excited to talk about their work and show off their posters, but the Dean initially zones in the student's shaky presentation skills. The result was a class full of bewildered students. How did the class turn this situation into a valuable learning experience and make the Dean happy on his next visit? How was the poster project handled the following semester to avoid the same issues? What happens when the excitement from other departments for your new contemporary algebra curriculum starts to vanish when registration issues arise as students realize that the class meets four days a week? The focus suddenly went from value of the new curriculum to frustration over scheduling. What was done to ease some of the scheduling problems, as well as regain support and build partnerships across the campus? This presentation will address these and other issues encountered in converting from a 3 day a week traditional college algebra program to a 4 day a week contemporary algebra program. (Received September 22, 2009)

1056-BC-2052 **Erick B Hofacker*** (Erick.B.Hofacker@uwrf.edu), 214C North Hall, River Falls, WI 54022. *Refocusing and reMODELING College Algebra - A Team Activity.*

Over the last five years, the idea of refocusing college algebra has grown within our department. It began with a few instructors trying to modify the focus of the course, so the emphasis was placed on the ideas of modeling and real-life applications rather than simply intricate skills and calculations. During the summer of 2009 we conducted an MAA PREP on our campus. By doing this, it encouraged some of our staff to participate in it and learn about teaching the course in a refocused manner. Our department now has a cohort of five instructors teaching over 1/3 of our sections in a refocused manner.

Part of the refocused philosophy is to create an environment where students work as part of a team, and peer communication is valued. This philosophy has transferred over to us as instructors too. We use team interactions to construct and mold the course. We conduct weekly team meetings. Each instructor contributes to the development of the course by creating: assessments, class exercises, technology-based activities, class notes, and clicker items. Some sections are team taught by two instructors. Appropriate technology such as graphing calculators, clickers, computer-based activities, and podcasts are integrated into each section. (Received September 23, 2009)

1056-BC-2053 **Erick B Hofacker*** (Erick.B.Hofacker@uwrf.edu), 214C North Hall, River Falls, WI 54022. *Making the Transition from High School Algebra to College Algebra.*

Algebra is thought of by many as the gateway course to future success in mathematics and quantitative fields. The NCTM Standards (2000) emphasize Algebra as one of the five main content standards all students should study throughout their K-12 math education. Yet so many students arrive at the university to have that door shut when taking a college algebra course, as DFW rates range anywhere from 30-60%.

This presentation will discuss similarities and differences between how algebra is presented and modeled at the high school and college level. Salient topics such as function, different model types, multiple representations, symbolic fluency, and real-life applications will be discussed. Integration of appropriate technology and the different ways technology is used at the two levels will be discussed. Special emphasis will be given to discussing how algebra can and should be viewed from both a procedural view and a conceptual one. The author will discuss his current work on a grant project that involves high school teachers and university faculty examining how to make students more successful in the transition between the two levels, especially within the content strand of algebra. Characteristics of students who are able to successfully transition will be shared. (Received September 23, 2009)

# *Online Delivery of Mathematics*

1056-BD-96 **Michael Speed*** (mspeed@tamu.edu), 9312 Lake Forest Ct South, College Station, TX 77845, and **Simon Sheather**, TX. *Online Delivery and the Use of Technology in the Classroom.*

This talk will look at various technologies used in teaching statistics to both undergraduate and graduate students as well as on-campus and distance students. We will start with our course management system (no we do not use WEBCT/Blackboard) and review a number of its features including the storage of class notes, streaming media, discussion boards and links. We will look at the online homework system and how we use proctors. We will show the use of our web conferencing software and how we use the Question and Answers sessions. Finally, we will describe how technology is used in our totally online Master's of Science in Statistics program. (Received July 26, 2009)

1056-BD-248 **Bernd S. W. Schroeder*** (schroder@coes.LaTech.edu), Program of Mathematics and Statistics, Louisiana Tech University, Ruston, LA 71272. *On-Line Delivery of Differential Equations: (How) Does It Work?*

Recent predictions about universities as we know them becoming obsolete are, in the presenter's opinion, quite wrong. This talk will discuss some fundamentals of on-line delivery of mathematical content, including what it can do and what it cannot do. In a nutshell, on-line delivery has benefits. Some of these benefits will lead to change, but on-line delivery will not be a cure-all. Suggestions will be given on the following topics. Tools to set up on-line presentations. Design and length of on-line presentations. Tools for homework submission. Administration of exams. Blended courses. Opportunities for positive change.

A rather therapeutic aspect of this talk is that most answers and suggestions are – in retrospect – quite obvious. The presenter hopes that this fact will help reduce anxiety of potential course designers as well as the scorn that some people (including, on some aspects, the presenter) may have for on-line delivery. The primary example will be an on-line differential equations course designed by the presenter. (Received August 19, 2009)

1056-BD-270 **Larissa Williamson*** (lwill@ufl.edu). *Successful on-line Math course: myth or reality?*

Teaching mathematics is not an easy task. Teaching mathematics on-line? Problematic.... Why are the students so anxious and the Instructors so skeptical about the on-line environment? Perhaps, the reason for the students' anxiety is a fear of being left alone with the Math and themselves; and for the Instructors, in their turn, not seeing the students is equivalent to losing them. The surprising thing, however, is that the well set on-line environment not only helps to overcome these anxieties but also creates models that reinforce the positive aspects in teaching Math and build healthy learning habits in the students, transforming them from passive observers into active learners.

In this presentation, I am describing a model of an on-line College Algebra course. There are several main aspects of this course that contribute to its success: communication, organization, easy access to the information, building a community.

From my experience of teaching thousands of students in on-line, hybrid, and in-classroom classes, I am convinced that on-line teaching of mathematics in skill building courses is not only possible but advantageous because it provides a friendlier learning environment to the students and gives the Instructors more tools for managing the course. (Received August 24, 2009)

1056-BD-584 **Michael E. Gage*** (gage@math.rochester.edu), Department of Mathematics, University of Rochester, Rochester, NY 14627. *WeBWorK: Open source on-line homework system for mathematics.*

I'll present an overview of WeBWorK, the open source on-line homework system designed specifically for mathematics and math intensive homework. On-line homework's immediate feedback makes a dramatic change in the amount of effort students put into doing homework and encourages them to ask focused questions in class and in office hours. WeBWorK can easily check answers which include functions, equations, and vectors as well as numbers and can be extended to check any answer whose correctness can be determined algorithmically. WeBWorK currently has a library of over 16,000 contributed problems and growing, including nearly every typical question used in calculus, precalculus, matrix linear algebra, differential equations and statistics courses.

Ongoing community projects are (1) to curate this question collection so that it is more profitable to find existing problems than to reinvent them and (2) to explore further the added dimensions that interactive electronic media provide beyond those available in book homework by incorporating flash, java and Geogebra applets into WeBWorK questions. (Received September 13, 2009)

1056-BD-1115 **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. *Electronic Study Guide – Maplets for Calculus.*

Students often purchase paper study guides to help them study precalculus, single and multivariable calculus and other math courses. The most well known are the Schaum's Outlines. Others hire expensive tutors. In between are the many online homework systems and the newer electronic study guides pioneered by the Maplets for Calculus (M4C). A problem with paper study guides is the small number of examples and students only get to read a full solution; there is no help in identifying the students' errors. Online homework systems are designed to produce grades and emphasize final answers. Correct solutions are displayed only after a grade is determined and there is no hint of their mistakes. Further there is very little variation between versions of a problem.

The M4C (See http://m4c.math.tamu.edu) are a collection of over 110 Maple applets emphasizing topics in pre-calculus and calculus. Each maplet is designed to ask a question and to provide step-by-step guidance through the solution, requiring correct answers to intermediate steps. Hints are available and when errors are detected, instructive feedback is provided. There are essentially an infinite number of problems on each topic. All of this enables students to use M4C as "a tutor without the tutor." (Received September 21, 2009)

1056-BD-1252 **Klaus Sutner*** (sutner@cs.cmu.edu), 5000 Forbes Avenue, Pittsburgh, PA 15213. *Computational Discrete Mathematics: Computation versus Bourbaki.*

CDM takes a fresh look at some of the standard concepts of discrete mathematics (relations, functions, logic, graphs, algebra, automata), with strong and consistent emphasis on computation and algorithms rather than the traditional axiomatic approach that has become popular in the second half of the 20th century. Another key concern is knowledge transfer: we try to build bridges between traditional mathematical concepts and the new computational universe powered by ubiquitous and cheap computation. Note that this process is fully bidirectional: computation helps to understand mathematics and mathematics informs computation.

The course entirely computer-held and is web accessible. A small part is also available in OLI format and we hope to achieve full conversion in 2010. (Received September 21, 2009)

1056-BD-1824 **Candace M Thille*** (cthille@cmu.edu), 5000 Forbes Avenue, Pittsburgh, PA 15213. *Evidence Based Course Design – The Open Learning Initiative at Carnegie Mellon.*

Using intelligent tutoring systems, virtual laboratories, simulations, and frequent opportunities for assessment and feedback, the Open Learning Initiative (OLI) at Carnegie Mellon builds dynamic, flexible, and responsive learning environments that foster robust learning. As students work through the OLI courses, we collect real-time, interaction-level data on how and what students are learning, and we use this data to create four positive feedback loops: to the student, to the instructor, to the course design team and to the learning science researcher. In this presentation will demonstrate how we make use of expertise and methods from the learning sciences to produce high-quality online courses. We will also discuss learning studies in which results have shown that students randomly assigned to the OLI statistics course learned a full semester's worth of material in half as much time and performed as well or better than students learning from traditional instruction. (Received September 22, 2009)

# *Scholarship of Teaching and Learning in Mathematics*

1056-BE-462 **Saad El-Zanati*** (saad@ilstu.edu), Campus Box 4520, Department of Mathematics, Illinois State University, Normal, IL 61790-4520, and **David Barker** (dbarker@ilstu.edu) and **Wendy O'Hanlon** (Wohanlon@icc.edu). *Research Experiences for Pre-service and In-service Secondary Mathematics Teachers.*

We will report on two NSF funded programs that involve pre-service (and in-service) secondary mathematics teachers in undergraduate mathematics research. One of the programs, the Teacher Scholar Program (TSP), is a capstone research experience. The second is a Research Experiences for Undergraduates Site (REU) for both pre-service and in-service teachers. Both programs are collaborative efforts between mathematicians and mathematics educators to provide teachers authentic mathematical experiences. The experience of doing mathematics has caused a change in our teachers' views of the nature of mathematics and subsequently their beliefs about teaching and learning.

In addition to the mathematical component of REU and TSP, we will discuss the educational topics that were connected to these mathematical experiences. For instance, we conducted an investigation of how middle school students develop mathematical generalizations, and the role that representations played in this process. In conclusion, we will present data that characterize the changes in our students beliefs and then provide an opportunity for the audience to discuss the role of authentic mathematical experiences in the preparation of mathematics teachers. (Received September 16, 2009)

1056-BE-1306 **Rikki B Wagstrom*** (Rikki.Wagstrom@metrostate.edu), College of Arts and Sciences, Metropolitan State University, 700 East Seventh Street, Saint Paul, MN 55106. *Assessing Student Learning in an Introductory-Level Mathematics Course with a Sustainability Emphasis.*

A pre-college algebra level course was taught with a curriculum which used quantitative reasoning and mathematical modeling to motivate and apply linear, exponential and logarithmic functions. Students used their quantitative reasoning, modeling and algebraic skills to quantitatively explore ecological footprints and limited resource availability within the U.S. This presentation will focus on a study designed to evaluate the effectiveness of the curriculum. In particular, the presenter will highlight the results from pre- and post-course assessments of student learning, interest in studying and using mathematics, and mathematical confidence level. (Received September 21, 2009)

1056-BE-1454 **Andrew G Bennett*** (bennett@math.ksu.edu), Dept. of Mathematics, Kansas State University, Cardwell Hall, Manhattan, KS 66506, and **Rachel Manspeaker**, **Danielle McNaney** and **Ala Alnaser**. *Differentiating Instruction in a Large Lecture Class.* Preliminary report.

A large lecture class like College Algebra will have students with a variety of interests and learning styles. This suggests that a variety of different sorts of assignments and teaching methods should be offered to different students. Managing this in a large lecture class can be challenging. In this talk we will discuss techniques to offer different options to different students efficiently and how these efforts affect student learning. (Received September 21, 2009)

1056-BE-1510 **Michael C Burke*** (burke@smccd.edu), Mathematics Department, College of San Mateo, 1700 W. Hillsdale Blvd., San Mateo, CA 94402. *Preliminary Thoughts on Quantitative Literacy.* Preliminary report.

It is generally acknowledged that we teach an overly broad mathematics curriculum; for motivation, we include applications selected to support that curriculum. The applications are often contrived, trivial, and of little interest or importance to our students. It is not clear that this curriculum meets the QL needs of the majority of our students. Although we bemoan the bloated state of the curriculum, it has been difficult to find an organizing principle around which to imagine genuine curricular change. I suggest a new approach: reverse the relationship between curriculum and applications. First, we ask "What are the important, compelling problems that our students will face in the future – problems such as global warming, nuclear waste, species extinction, world population?" We follow with the question "What mathematics must our students know in order to be able to address these problems?" That is, I propose that we use compelling, non-mathematical problems to drive our mathematics curriculum. In my experience, this approach leads to much greater student interest. I plan to illustrate with assignments I have used at the College of San Mateo, to look carefully at student work and response, and to discuss implications of this approach for the teaching of QL. (Received September 22, 2009)

1056-BE-1719 **Kathryn T Ernie*** (kathryn.t.ernie@uwrf.edu), Department of Mathematics, 207 NH, University of Wisconsin - River Falls, 410 South 3rd Street, River Falls, WI 54022. *SoTL in the Mathematics Content Preparation of Teachers: Infusing K-12 Exemplars in the Undergraduate Mathematics Curriculum.*

Mathematics faculty at the University of Wisconsin-River Falls have received five grants in support of SoTL projects infusing K-12 exemplars into mathematics content courses. These projects were supported by a grant of the University of Wisconsin System PK-16 Initiative on Teacher Quality. Over the past three semesters approximately 150 undergraduates in geometry, statistics, history of mathematics, and content for future elementary teachers have participated in these projects along with five K-12 consultant teachers. The projects are diverse and range from a focus on reasoning and proof, modeling, and the use of interactive materials in a laboratory setting. This presentation will review these efforts, lessons learned, and the impact on the curriculum. (Received September 22, 2009)

1056-BE-1832 **Rose Asera*** (asera@carnegiefoundation.org), Carnegie Foundation, 51 Vista Lane, Stanford, CA 94305. *What is inquiry? What is evidence?*

The Carnegie Foundation for the Advancement of Teaching organized Strengthening Pre-collegiate Education in Community Colleges (SPECC), an action research project. Faculty at participating colleges created faculty inquiry groups. In these setting mathematics faculty collaboratively examined their own teaching and their students' learning. Three examples from this work– think-alouds, classroom observations, and examples of student work–will be presented to illustrate different ways that faculty members looked more deeply into what they took as evidence of student learning in developmental mathematics. (Received September 22, 2009)

# Mathematics of Origami

1056-BF-1057 **Thomas C. Hull*** (thull@wnec.edu), Mailbox H-5174, Western New England College, 1215 Wilbraham Road, Springfield, MA 01119. *Combinatorial Methods in Flat Origami.*

How does paper fold flat? What rules are at play when paper is folded into a flat origami object? One way to approach this question is to make combinatorial and geometric connections between the crease pattern on the unfolded sheet and the final, flat-folded state of the paper that results. This talk will survey such connections, including the theorems of Maekawa, Kawasaki, and Justin. We will see how these results allow us to almost completely characterize and enumerate the single-vertex case and provide much insight into multiple-vertex flat-foldability. The emphasis in this talk will be on new interpretations of these results and on further avenues of study that they reveal. (Received September 20, 2009)

1056-BF-1225 **Tamara B Veenstra*** (tamara_veenstra@redlands.edu), 1200 E. Colton Avenue, Department of Mathematics, University of Redlands, Redlands, CA 92373. *Paper Folding, Orders of Elements, and Binary Representations of Fractions.*

Many origami designs begin with instructions to divide a piece of paper into 5ths, 7ths, or other nths. Since traditional origami does not allow the use of a ruler or any device other than the paper itself, this might seem impossible. However, the Fujimoto technique is an ingenious method to approximate 1/nth of the paper for any odd n using only the given piece of paper. In the easiest case for paper folders, this technique sometimes produces crease lines at all multiples of 1/n, thus completely dividing the paper into nths. At other times, applying this algorithm produces crease lines at only some of the multiples of 1/n requiring the folder to do more work to completely divide the paper into nths. This paper will describe some mathematics, primarily number theory, underlying the Fujimoto method. As a consequence we will see how origami highlights a well-known connection between binary representations and arithmetic mod n. We will also generalize this connection to any base producing different (albeit impractical) methods of finding 1/nth of the paper. (Received September 21, 2009)

1056-BF-1242 **Roger C. Alperin*** (alperin@math.sjsu.edu), Dept. of Math., San Jose State University, San Jose, CA 95192. *Bisections, Trisections and Quintisections by Origami.* Preliminary report.

I will discuss construction axioms for origami folds and their relation to ordinary ruler and compass constructions in the plane. The origami axioms also allow a simple fold which gives an angle trisection or more generally can solve a cubic equation. This fold is related to an algebraic curve of degree three. More complex or multi-folds have also been investigated. These multi-folds give methods for an angle quintisection. The quintisection can also be achieved as the intersection of two cubic curves. (Received September 21, 2009)

1056-BF-1497 **Robert J. Lang*** (robert@langorigami.com), 899 Forest Lane, Alamo, CA 94507.
*Mathematical Methods in Origami Design.*

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, and tap into diverse mathematics ranging from Euclid up to the latest developments in computational geometry.

In this talk, I will describe how geometric concepts have led to the solution of a broad class of origami folding problems, including the problem of efficiently folding a shape with an arbitrary number and arrangement of flaps, and new geometric forms known as "origami tessellations." Along the way, mathematical methods have 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, lifesaving medical advances, and more. (Received September 22, 2009)

1056-BF-1946 **Erik D. Demaine*** (edemaine@mit.edu), MIT CSAIL, 32 Vassar St., Cambridge, MA 02139, and **Martin L. Demaine** (mdemaine@mit.edu), MIT CSAIL, 32 Vassar St., Cambridge, MA 02139. *Computational Origami from Science to Sculpture.*

Our understanding of the mathematics and algorithms behind paper folding, and geometric folding in general, has increased dramatically over the past several years. These developments have found a surprisingly broad range of applications. In the art of origami, it has helped spur the technical origami revolution. In engineering and science, it has helped solve problems in areas such as manufacturing, robotics, graphics, and protein folding. On the recreational side, it has led to new kinds of folding puzzles and magic. I will give an overview of the mathematics and algorithms of folding, with a focus on new mathematics and sculpture.

Our approach is unusual in the way we combine art and science. We have found these two disciplines to be converging more and more in our minds. No longer do we have separate art projects and mathematics projects: many of our projects have both artistic and mathematical angles, and we pursue both. The art and mathematics inspire each other: building sculpture inspires new insights into the mathematics, and mathematical understanding inspires new sculpture. (Received September 22, 2009)

1056-BF-1996 **Ileana Streinu*** (istreinu@smith.edu), Computer Science Department, Smith College, Northampton, MA 01063. *Rigid origami.*

The mathematical study of origami faces many challenging questions. Most of the research has so far focused on understanding, axiomatically, the possible folding patterns of creases. But once the pattern is given, how do we fold the flat paper to a three-dimensional shape? The constraints here are: (a) topological: the paper cannot be cut or torn; (b) (geo)metric: the paper cannot be stretched or shrunk, i.e. its intrinsic metric is preserved. In rigid origami, we add a few extra, rigidity-theoretic assumptions: (c) we cannot introduce new creases, and (d) each face of the crease pattern remains flat throughout the folding process. The creased paper becomes a panel-and-hinge structure, where the individual faces can rotate (pivot) about the creases, which are viewed as hinges.

I will give an overview of what is known about the folding of single-vertex rigid origami, based on my joint work with Gaiane Panina and Walter Whiteley. (Received September 22, 2009)

# *Arts and Mathematics*

1056-C1-157 **Robert Edward Lewand*** (rlewand@goucher.edu), Department of Mathematics & Computer Science, Goucher College, 1021 Dulaney Valley Road, Baltimore, MD 21204. *A Mathematical Tour of Baltimore.*

In this talk I will describe both verbally and visually the results of my project to seek manifestations of mathematics as they appear in both the natural and built environment in the various neighborhoods that I inhabit. Examples will be drawn from the areas of art, architecture and nature and most fall into the overlapping mathematical categories of geometry, tessellations, functions, and fractals. Most of the photographs included in this presentation were taken in Baltimore, Maryland. (Received August 06, 2009)

1056-C1-177 **Mingjang Chen*** (mjchen@mail.nctu.edu.tw), 1001 Ta-Hseu Rd, Hsinchu, 300, Taiwan. *Exploring Chaotic Patterns in Chinese Landscape Paintings by Structural Cloning Method.* Preliminary report.

A new method by using Structural Cloning Method (SCM) and Leaping Iterated Function System (LIFS) to explore chaotic patterns in Chinese Landscape Paintings, one of the oldest artistic traditions in the world, is introduced in this talk.

SCM is a visual interface to define different combinations of geometry transformations and LIFS is an improved version of Iterated Function System (IFS) within SCM. Instead of exponential growing loading while iterating; LIFS takes only constant computing resources. From the viewpoint of visual design, SCM and LIFS together build a bridge between mathematic and aesthetic, and they then make fractals more tractable. Moreover, we also find that some of chaotic patterns in Chinese Landscape Painting are convertible.

A few pieces of Chinese Landscape Paintings will be demonstrated in this presentation to show how SCM and LIFS work by implementing SCM as a core function in animated (AMA) on PowerPoint. (Received August 12, 2009)

1056-C1-299 **Susan A. McBurney*** (SMcBurne@iit.edu), 211 Rugeley Road, Western Springs, IL 60558. *The Joy of the Curve.*

The beauty of curved shapes has intrigued scholars for thousands of years. Beginning with Hippocrates of Chios' 4th century B. C. quadrature of two lunes of a right triangle, this presentation will examine a variety of ingenious geometric proofs involving curved areas. Then it will touch upon Leonardo DaVinci's fascination with "lunulae", and lastly will showcase the work of turn-of-the-century architect Louis Sullivan, whose original building ornamentation celebrated the design possibilities of curves in all their glory. (Received August 26, 2009)

1056-C1-301 **Reza Sarhangi*** (rsarhangi@towson.edu), Mathematics Department, Towson University, 7800 York Building, Towson, MD 21252. *A Brief Study of Modularity in Mosaic Designs.*

Based on some older documents we may claim the compass-straightedge geometric construction as one of the main methods for creating mosaics designs. However, other methods, such as "cutting and pasting" of tiles and "modularity", should be considered as alternatives used by the artisans. This presentation demonstrates some ideas about making patterns and designs in Persian mosaics using cutting and pasting and "modularity" of single-color tiles. The predominance of geometry constructions of compass-straightedge in medieval Persian art exhibits both the "artisans' skills" and the "direct involvement of mathematicians" in the pattern making process. Nevertheless, the goal of this presentation is to study other design-making approaches that perhaps are much older than the domination of sophisticated geometry in making ornamental designs. We first give a summary of the idea of "modularity", and then present other related methods. (Received August 26, 2009)

1056-C1-353 **Anne M. Burns*** (aburns@liu.edu), Department of Mathematics, Long Island University, C.W. Post Campus, 720 Northern Blvd., Brookville, NY 11548. *Visualizing the Dynamics of the Unit Circle Group.* Preliminary report.

The Unit Circle Group is a subgroup of the group of Möbius transformations that maps the unit disk to itself. An element of this subgroup is determined by three real parameters. We create Iterated Function Systems made up of transformations of the plane composed with functions from the Unit Circle Group. Then, "continuously" varying the three parameters, we make animations that illustrate the complexity of the dynamics. Finally we show how to use a continuous ramp of color to enhance the animations. (Received September 01, 2009)

1056-C1-382 **Peter N Wong*** (pwong@bates.edu), Department of Mathematics, Bates College, Lewiston, ME 04240. *What is sangaku?* Preliminary report.

During the national seclusion (1641-1853) or Sakoku when Japan was isolated from the West, the traditional Japanese mathematics (wasan) flourished. Appearance of sangaku helped popularize wasan. Mathematical votive tablets (sangaku) were hung under the eaves of shinto shrines and buddhist temples. Many of these sangaku were beautifully drawn with geometric figures painted in bright colors. Sangaku can be regarded as a form of publication during the Edo period as well as objects of the Arts. A sangaku dating back to 1885 was recently discovered (June 2009) in a small village in Fukushima prefecture, Japan. In this talk, I will give a pictorial introduction to sangaku and the mathematical problem contained in this recently discovered sangaku. (Received September 03, 2009)

1056-C1-392 **Jeffrey M Groah*** (jeffrey.m.groah@lonestar.edu), Mathematics Department, 3200 College Park Dr., Conroe, TX 77381. *Monument to Error, Perspectives: The Love of Form, and Solution Set.*

Three recent works are presented. The Monument to Error conveys the idea that our successes are founded upon our mistakes. Perspectives: The Love of Form illustrates how perspective can completely change one's interpretation of a form. Solution Set is a stiking form that is also the solution set of an inequality in two variables. (Received September 03, 2009)

1056-C1-461 **Meighan I. Dillon*** (mdillon@spsu.edu), Mathematics Department, SPSU, 1100 S. Marietta Pkwy, Marietta, GA 30060. *Projective Geometry and The Art of The Renaissance.*

During the 15th century, Renaissance artists learned to use perspective mappings to represent three dimensional scenes on two dimensional walls and canvases. Perspective mappings turn out to be a critical element in the theory of projective spaces, which turn out to be the most natural setting for studying Euclidean geometry. In spite of a protracted flirtation with projective geometry, though, mathematicians did not discover a theory of projective spaces until 200 years after Renaissance artists started learning to use perspectivities. In this talk, we consider the gap between art and mathematics, as well as how it was resolved, over a theory that has proved as critical to the study of geometry in modern times as it has to the art and craft of representational painting. (Received September 08, 2009)

1056-C1-591 **Helmer Aslaksen*** (aslaksen@math.nus.edu.sg), Dept of Mathematics, National University of Singapore, Singapore, 117543, Singapore. *Modular Perspective in The Music Lesson by Vermeer.* Preliminary report.

Many people have used the image of the back wall in the mirror in the painting The Music Lesson by Johannes Vermeer (1632-1675) to try to estimate the size of Vermeer's studio. In this talk we will focus on a series of interesting papers by the architect Tomás García-Salgado, using a technique he refers to as modular perspective. Unfortunately, the explanations may be hard to understand for mathematicians, and we will discuss his methods and results in a way that will hopefully be easier to understand for mathematics students. (Received September 14, 2009)

1056-C1-749 **Melanie Anne Pivarski*** (mpivarski@roosevelt.edu), Roosevelt University, Mailstop AUD520, 430 S. Michigan Ave, Chicago, IL 60605. *Dancing and Groups: An Active Activity.* Preliminary report.

Dancing is a fun way to connect group theory and movement. We'll create a dictionary between mathematical terms (like finite group, generating set, permutations, even, odd) and dance moves (like circle left, swing). We'll discuss some questions that can be asked and answered such as: What configurations are possible? Given a set of possible dance moves, what groups can we get? Are dances even or odd? This activity can be used for students of all levels. A "cheat sheet" will be provided for instructors. (Received September 16, 2009)

1056-C1-872 **William Goldbloom Bloch*** (bbloch@wheatonma.edu), Department of Mathematics, Wheaton College, Norton, MA 02492. *The topology of Jorge Luis Borges'* Library of Babel..

*The Library of Babel* is one of Jorge Luis Borges' most famous and most evocative works. A key aspect of the story is that the narrator lives in a Universe composed of hexagonal rooms functioning as a "total" Library. The narrator states his received belief that the Library is a sphere whose consummate center is any hexagon and whose circumference is unattainable. (Many commentators have noted that this echoes an epigram of Pascal.) Late in the story, the narrator adduces a few ideas of his own about the structure of the Library.

In this talk, I will outline some candidate manifolds for Library that satisfy the different beliefs propounded by the narrator. (Received September 18, 2009)

1056-C1-950 **Vladimir L. Bulatov*** (info@bulatov.org), 2970 Christine Street, Corvallis, OR 97330. *Conformal Models of Hyperbolic Geometry.* Preliminary report.

We show different ways to visualize hyperbolic patterns using conformal transformations of the complex plane. Traditional Poincare model of hyperbolic plane has a lot useful properties, but has limited visual appearance. Image of a pattern in Poincare model is a circle with a few large images at the center and rapidly vanishing details toward the boundary. This is especially inconvenient for patterns with large fundamental domains. However, Poincare circle can be conformally mapped into a variety of shapes to produce quite different and interesting images. Several examples will be presented, in particularly infinite band, ring, sector and a few more artistic shapes. Different mappings provide various visual advantages for pattern visualization. Infinite band for example visualize patterns with constant scale along the center line. The pattern visualization in the band model may

be periodic along the band or exhibit infinite variety of shapes depending on where in the hyperbolic plane the axis of the band mapping is located. The band mapping also can be generalized for use in the visualization of 3D hyperbolic geometry. In that case the Poincare ball is stretched into an infinite cylinder. This mapping is quasi-conformal with the anisotropy factor close to one. (Received September 18, 2009)

1056-C1-1020 **Rosanna Iembo*** (`rosannaiembo@libero.it`), via Federico Cozzolino 18, 84018 Scafati, Salerno, Italy, and **Irene Iaccarino**, via Interna Marina 19, 88900 Crotone, Italy. *ONCE UPON A TIME THERE WAS...... A epistemological "fable" of music and mathematics.*

It is said that Pythagoras, influenced by his travels in the ancient East, was convinced that music could influence on the moral behaviour of the persons. In his Pythagorean School this conception became a particular doctrine : the ethos doctrine. Such doctrine indicated the relations between music and the moods and also the respect of the rules and of the behavioural principles (the "paideia"). So all is number : but a number which is poetry, epistemology, philosophy, mathematics and music together. You will wonder why in the third millenium, we are here to tell these things and what is the link among Pythagoras, the violinist and me. Is very simple : we come from the city where Pythagoras founded the Pythagorean School and where he lived for forty years: Crotone, in the southern Italy. Being "followers" of his School we have learned to travel and love the intercultural dialogue and to think of mathematics as poetry which you can neither write nor read without a yearning musical "meditation". During the presentation of this work the violinist will play classical music live (Received September 20, 2009)

1056-C1-1236 **Alan Levine*** (`alan.levine@fandm.edu`), Department of Mathematics, P.O. Box 3003, Lancaster, PA 17604. *The Mathematical Development of Music.*

The development of music throughout history may be viewed as proceeding from the continuous to the discrete - that is, from the continuum of pitches created by a vibrating string or air column to the discrete subsets, or scales, that form the basis of most music. This is the opposite of the development of mathematics which, according to Kronecker, began with discrete integers and proceeded to the continuum of the real numbers and beyond. We will discuss how this idea is used as the basis for a general education course on the science of music that the author teaches. (Received September 21, 2009)

1056-C1-1246 **Joshua P. Case*** (`joshua.case@maine.edu`), P.O. Box 71, New Vineyard, ME 04956. *Measuring Complexity of d-Note Pitch Collections Within a c-Note Chromatic Universe.*

Music theorists describe the complexity of pitch-class sets (collections of musical notes) by computing the number of "differences", "ambiguities", and "contradictions" found among the generic intervals. Norman Carey has developed a formula to determine the maximum number of differences for sets of cardinality N. However, due to the restrictions of the $c$-note chromatic universe in which a $d$-note pitch-class set is contained, this maximal value may not be reached. I desire to develop a formula that will yield the maximum number of differences given the values $d$ and $c$. If such a formula can be developed, what can it reveal about a set's chromatic universe and its ability to contain complex collections? What will this formula tell us about the collections themselves? While differences will be a main focus, other formulas dealing with complexity (incorporating both $c$ and $d$) will also be considered. (Received September 21, 2009)

1056-C1-1320 **Benjamin Wells*** (`wells@usfca.edu`), Department of Mathematics, University of San Francisco, 2130 Fulton Street, San Francisco, CA 94117. *Mathematics, art, and the Fusion Project.* Preliminary report.

The Fusion Project (FP) is a research effort of the University of San Francisco, envisioned by Philip Wagner, directed by Benjamin Wells, and established as a distinct program of the College of Arts and Sciences with the collaboration of the School of Education. Supported by the Fine Arts Museums of San Francisco (FAMSF), FP will take their art to the middle school math classroom and math students to their de Young Museum. Workshop-trained teachers will bring FP techniques and materials to their 7th grade classrooms, utilizing FAMSF resources by showing high-resolution imagery in class and visiting the museum on field trips. We seek to enhance existing curricula in order to improve basic and advanced skills, standards-oriented test scores, and students' interest in math. Anticipated collateral outcomes are improved appreciation of art combined with an awareness of how mathematics enriches both the execution and understanding of art.

There are two current and future research aspects: (1) Alignment methodology has identified target standards and convinced FAMSF that their collections are appropriate channels for math education. (2) Once FP is operating in classrooms, we have the opportunity to study the effectiveness of FP for the stated purposes. (Received September 21, 2009)

1056-C1-1405 **Suzanne Galayda*** (sgalayda@nmsu.edu) and **Alexandra D'Italia**. *Writing Critically with Enthusiasm for Mathematicians.*

Mathematicians are no strangers to writing. Yet the standard top to bottom writing process of outline, draft, and rewrite often fails when the object to be written is an article or dissertation. Writers of all types can get caught in between their enthusiasm for the subject and their inner critic. We often call this writer's block. In this talk, we discuss ways to harness that enthusiasm and the inner critic to set ideas on paper and proceed toward the finished object. We reconsider the role of the first draft and the process of revision. In doing so, we examine the roles a writer assumes during the writing process: The Madman, The Architect, The Carpenter and The Judge. We discuss how applying these roles outside of a top to bottom writing format can facilitate clear, concise, critical writing with more ease than standard approaches. (Received September 21, 2009)

1056-C1-1410 **Jeff Chyatte*** (Jeff.Chyatte@montgomerycollege.edu), 7600 Takoma Avenue, Takoma Park, MD 20912. *Hyperbolic Conic Section through Kinetic Sculpture.*

The Science, Math and Art or SMArt project connecting conics sections and art provides a novel 3D demonstration of the hyperbolic path of an inclined rod rotating through a vertical plane. The inclined rod was connected at its center to a horizontal arm, which in turn is connected to a rotating vertical axis. As it is rotated, the inclined rod passes through a vertical plane, cutting in it a portion of a perfect hyperbola. To establish the standard hyperbolic equation, the length of the horizontal arm was designated r, the inclined rod forms an angle alpha with the horizontal, theta measures the rotation of the arm about the vertical axis, theta = 0 as the position where the horizontal arm lies in the half-plane and theta is measured counterclockwise when viewed from above. If the arm meets the vertical axis at the origin, and the half-plane is given by y = 0 and x > 0, then point of intersection of the inclined rod with the half-plane can be parameterized (as a function of theta) via x = r sec theta and z = – r tan alpha tan theta. The identity sec2 theta – tan2 theta = 1 can then be used to put the resulting curve into the standard hyperbolic form.

The sculpture "Theorem" by Jeff Chyatte was featured in Touchstone Gallery Washington, DC and Math Horizons Magazine April 2009 (Received September 21, 2009)

1056-C1-1457 **Fatma Mete** (fm95@cornell.edu), Cornell University, ithaca, NY 14850, and **Yurekli Osman*** (yurekli@ithaca.edu), Ithaca College, ithaca, NY 14850. *Digital roots, Vedic multiplication and Fibonacci numbers.*

Consider a number n, add the digits of numbers derived from it, and continue the process until the remaining number has only one digit. This single digit result is called the digital root of n. In this presentation the connection among the digital root, the Vedic multiplication tables and visual representations of numbers will be discussed. Extending these ideas to Fibonacci numbers and other well known integer sequences give rise to interesting geometrical designs. The geometrical designs are obtained using the computer algebra system Mathematica and the spread sheet program Excel. We will show some of these designs and explain how they are created. (Received September 22, 2009)

1056-C1-1547 **Barbara A. Ashton*** (bashton@bmcc.cuny.edu), 199 Chambers Street, N529, New York, NY 10007. *Modeling Heraldic Design Using Shape Grammars.* Preliminary report.

Heraldry is the science that studies arms, the colored emblems that are used to represent individuals, families or communities. Blazon is the set of rules that govern the composition of arms. In this presentation, the author will present a shape grammar (a set of shapes and functions defined on those shapes) that describes the rules of blazon. (Received September 22, 2009)

1056-C1-1580 **Fatma Mete*** (fm95@cornell.edu), Ithaca, NY 14850, and **Osman Yurekli** (yurekli@ithaca.edu), Ithaca, NY 14850. *Empirical Origin of the Design Concepts and the Euclidean Geometry.*

Creative design makes use of geometry in the establishment of its fundamental concepts. We argue that the three-dimensional nature of space as well as its Euclidean character is of empirical origin, and that this can be demonstrated and tested in the framework of actual design processes. Design is continually calculating relations of space of the most varied kind by geometrical principles and the success of its construction agree with these calculations. We present a demonstration from fabric design field to show the empirical sources of these concepts, their formations and their spatial patterns of relationships. Our ultimate aim is to develop the invariants of design and creative process, and to bring the formal side of design and art within the purview of mathematics. (Received September 22, 2009)

1056-C1-1757 **Debra L. Hydorn*** (dhydorn@umw.edu), 1301 College Avenue, Fredericksburg, VA 22401. *Group explorations and art projects in a mathematics of art course for first-year students.*

I was a participant in the 2008 MAA PREP Course on Geometry and Art and have successfully created my own first year seminar based on that on-line course. In this presentation I will provide an outline of the course content, which draws on the resources of the PREP course website and the web textbook the course instructors have created. I will then describe the group exploration activities I created to allow students to discover the mathematics behind the work of M.C. Escher and other artists, and the course blog where students take turns writing about the mathematics they found through these activities. I will also describe the two course art projects and group art exercises from the course. (Received September 22, 2009)

1056-C1-1789 **Lisl Gaal*** (gaal@math.umn.edu). *Lithographs Representing Some Mathematical Topics.*

We present some hand-drawn, hand-printed and hand-colored lithographs incorporating mathematical ideas such as the Pythagorean Theorem, Gaussian primes, Desargues' Theorem, Riemann sums, and the permutation group on three elements. (Received September 22, 2009)

1056-C1-1801 **Douglas E. Norton*** (douglas.norton@villanova.edu), Department of Mathematical Sciences, Villanova University, 800 Lancaster Avenue, Villanova, PA 19085. *Further Aesthetic Explorations in Phase Space.*

We investigate the aesthetic potential of some graphical interactions of phase portraits of parameterized families of systems of differential equations in the plane. (Received September 22, 2009)

1056-C1-1887 **Valerie Ng** (ngv@beloit.edu), B-09-05 Opal Damansara Condo, Jalan PJU 3, Sunway Damansara, Malaysia, and **Darrah Chavey*** (chavey@beloit.edu), Beloit College, 700 College St., Beloit, WI 53511. *Symmetry Preference and Meaning in Tibetan Sand Mandalas.*

Tibetan sand mandalas generally have a 4-fold symmetry on the main elements of their designs. But looking more closely, we can see additional symmetries on individual elements within the mandala. The statistical distribution of these symmetries is quite different from what we see in other art forms, and apparently reflects purposes of the design. In addition, there are "near-perfect" color-interchanging symmetries where the violations of perfect color symmetry reflect both the construction techniques for the mandala and cultural values of the Buddhist monks who created it. Mathematical techniques thus give us the ability to gain additional cultural meaning from these designs that is not always apparent from traditional artistic and cultural analysis. (Received September 22, 2009)

1056-C1-1955 **Ann Robertson*** (arob@conncoll.edu), Connecticut College, Box 5378, 270 Mohegan Avenue, New London, CT 06320. *A Feigenbaum Face.*

Examples of the Golden Mean abound in nature; the human face is frequently offered as a further illustration of its use. Can one imagine different constants being present in a face, perhaps a stylized one? Just for fun, the Feigenbaum delta and alpha constants of chaos theory were considered. The first constant, discovered in 1975 by Mitchell Feigenbaum, is approximately equal to 4.6692. For a period doubling bifurcation diagram, of say the logistic map, it is the limiting ratio of successive interval lengths given the onset of mathematical chaos. The second Feigenbaum constant, approximately equal to 2.5029, is the limiting ratio of widths of successive branches given a particular point of measurement (critical point). My two pastel stylized faces are drawn to illustrate the constants. The first sketch that will be presented was modeled after a "Head of a Caryatid" drawn in blue crayon by Amedeo Modigliani in 1909. Then Modigliani's sculptures of very elongated heads, carved in stone from 1909 to 1917, provided models for lengthening the face. My final sketch illustrates how the second Feigenbaum constant can be obtained. The various line segments involved in the calculation of the Feigenbaum constants were constructed and measured using Adobe Illustrator. (Received September 22, 2009)

1056-C1-2010 **Karl H. Schaffer*** (karl_schaffer@yahoo.com), P.O. Box 8055, Santa Cruz, CA 95061. *Dancing in Mathematical Circles.*

Although choreographers may employ mathematical principles when creating dances, overt attention is seldom given to the mathematics by either the audience or the choreogrpaher. We will examine the mathematical elements in several of the author's recently choreographed dances in which mathematical ideas were embedded purposefully and with the intent that the mathematics be at least somewhat visible to the audience. These include the show "Harmonious Equations," directed by Keith Devlin, which celebrates important equations of math and physics in song, prose, and dance; and "The Magic Circle," a dance for outreach performances to schools, both premiering in the past year. New work to be outlined includes "dancer tessellations," which the author is currently working on, and "Switch," a recent dance about genetic engineering which plays with the 24 permutations of 4 dancers in a line. (Received September 22, 2009)

1056-C1-2011 **Pedro Teixeira*** (pteixeir@knox.edu), Knox College, Mathematics Department, 2 E South Street, Galesburg, IL 61401. *The Great Calculus II Art Contest.*

After many years spending countless (happy) hours creating neat curves and surfaces to show my Calculus students—who often go "Wow!" and are surprised to find beauty in math—I finally decided to go a step further and let the students join the fun. The "Great Calculus II Art Contest" was created! In this talk I report the outcomes, both artistic and mathematical, of this experience. (Received September 22, 2009)

1056-C1-2131 **Rebecca E Field*** (fieldre@jmu.edu), MSC 1911, Department of Mathematics, Roop Hall, James Madison University, Harrisonburg, VA 22807. *Material Properties of hyperbolic space in relation to history of clothing.* Preliminary report.

I will present on the difficulties of constructing covers that conform to a saddle surface. In particular, I will talk about various solutions that have been offered and their history in regards to clothing as well as talking briefly about the same problem for less flexible materials such as sheet metal for armor. (Received September 23, 2009)

# *Developmental Mathematics Education: Helping Under-Prepared Students Transition to College-Level Mathematics*

1056-D1-223 **Melanie Joyno Orig*** (melanie_orig@yahoo.com), Block 10, Lot 32 Apricot St,Ciudad de, Esperanza, Buhangin, 8000 Davao, Philippines. *College Mathematical Readiness of the Senior High School Students of the Public Schools in District I of Davao City, Philippines.*

The purpose of this study is to determine the level of mathematical proficiency of the senior high schools students enrolled in the public schools of District I in Davao City. It also sought to determine the level of readiness of the students for college mathematics. The students were given the mathematics achievement test where the contents include Number Sense, Geometry, Probability and Statistics, Algebra and Functions. The findings of the study were used to come up with a bridging program sponsored by the University of Mindanao as part of its community extension to help the incoming freshmen college students prepare for college mathematics. (Received August 16, 2009)

1056-D1-224 **Jack A Carter*** (jack.carter@csueastbay.edu), Mathematics Dept, California State University East Bay, 25800 Carlos Bee Blvd, Hayward, CA 94542-3092, and **Beverly J Ferrucci** and **Ngan Hoe Lee**. *Proportional Reasoning Models in Developmental Mathematics Education: Enhancing Under-Prepared Students' Transition at the College-Level.* Preliminary report.

A study of undergraduates in Singapore and the United States revealed superior performance by the Singaporeans on proportional reasoning problems. Analysis of solutions showed the Singapore college students were more likely to use unitary and benchmark approaches than were their American counterparts. Conclusions include suggestions for programs intended to improve the transition for under-prepared students to college-level mathematics on proportional reasoning problems. (Received August 16, 2009)

1056-D1-233 **Robert E Burks*** (reburks@nps.edu), 336 Fitch Ave, Monterey, CA 93940, and **Eric W. Drake** and **Elizabeth Schott**. *"Rock Math" a Successful Implementation of a Curriculum Designed to Help Under-prepared Students make the Transition to College Mathematics.*

All students entering the United States Military Academy, regardless of major, are required to take a two year four semester mathematics sequence which includes single, multi-variable Calculus, and Probability and Statistics. Every year approximately 5 percent of the freshmen class enters under-prepared for success in the school's math sequence. These students are enrolled in a yearlong developmental mathematics course affectionately referred to by the students as "Rock Math". This course is designed to alleviate student math-anxiety, the fear of math, and develop organizational and learning skills, while nurturing student creativity, critical thinking, and application of technological tools in a problem solving environment. This presentation focuses on the structure of the course, classroom practices and techniques to prepare our students for success in future math and engineering classes, and an assessment of our outcomes. (Received August 26, 2009)

1056-D1-567 **Stuart Boersma*** (boersmas@cwu.edu), Department of Mathematics, Central Washington University, 400 E University Way, Ellensburg, WA 98926, and **Aaron Montgomery**.
*Transition Mathematics: A Professional Learning Community Approach.*

In 2006, a professional learning community comprised of teachers from high school, two-year, and four-year colleges was formed to investigate numerous issues associated with the transition from high school to college level mathematics in rural Washington. Over the course of three years the PLC examined curriculum alignment, studied college placement procedures, developed a new senior level high school course, and hosted professional development opportunities. This paper will present details on the formation of the PLC and the changes made at both the high school and college level to help student with the transition to college level mathematics. (Received September 13, 2009)

1056-D1-602 **K. Scott Alberts*** (salberts@truman.edu), Truman State University, 100 E. Normal Street, Kirksville, MO 63501, and **Jane Roads** (janer@macc.edu), Moberly Area Community College, 101 College Avenue, Moberly, MO 65270. *How ideas from therapy can help developmental mathematics students with anxiety, motivation, and performance: Successes from two pilot tests.* Preliminary report.

Cognitive Behavioral Therapy (CBT)is widely used to help people with anxiety, phobia, and depression. It is based on learning how to think objectively about oneself, identifying unhealthy behaviors, attitudes, and thoughts, and working to replace the unhealthy things with healthy ones. Three techniques common to CBT are journaling, agenda setting, and relaxation techniques. Can these ideas be used to help developmental mathematics students? Can developmental mathematics teachers be trained to use these ideas without formal counseling training? Preliminary data is promising, and we will present some ideas from our early that may be helpful in the classroom. (Received September 16, 2009)

1056-D1-794 **Michael H Davis*** (micdavis@berkeley.edu). *Understanding and addressing the social/emotional needs of learners with histories of difficulty in mathematics.*

This presentation integrates a series of studies conducted by the author (Davis, 2008; Davis, in press) and a larger body of research on learning to explore factors that shape students' engagement and participation in mathematics. A sociocultural theoretical framework is used that supports a full consideration of the complex ecology of learning environments. More specifically, the presentation examines how students' identities, beliefs, and emotions interact with curriculum and pedagogy and shape the ways students engage and disengage in mathematics. Particular attention will be given to how these factors affect students with histories of difficulty with mathematics. The presentation will also consider approaches that have been found to promote more productive and sustained engagement for these students. These strategies include supporting changes in: beliefs about the nature of intelligence, definitions of mathematical competence, and expectations for mathematical activity. Ways to develop meta-cognitive skills, including emotion regulation, cognitive monitoring, and goal setting will also be considered. Methods for implementing these strategies in the college context through course work and support programs will be considered. (Received September 17, 2009)

1056-D1-809 **Kimberly J Presser*** (kjpres@ship.edu), Shippensburg University, Department of Mathematics, Shippensburg, PA 17307. *Developmental Mathematics and Assessment: Where have we come from? Where are we now? Where are we going?* Preliminary report.

Formal instruction in Developmental Mathematics began at Shippensburg University in the fall of 2003. Our overriding goal has been to provide remediation which will help those students in the Developmental Mathematics program move into a college level mathematics course and be successful at a rate similar to the overall success rate in the given course. Using our assessment data we have made several changes to the method of instruction that we provide in order to better attain this goal. The purpose of this session is to discuss how our Developmental Mathematics program has evolved over the years and the role that assessment has played. In addition, we will discuss some of the newest changes to the program and what we hope to see in the future. (Received September 17, 2009)

1056-D1-881 **Christine L. Ebert** (cebert@math.udel.edu), 312 Ewing Hall, Department of Mathematical Sciences, University of Delaware, Newark, DE 19716, **Donna A. Mark*** (mark@math.udel.edu), 114 Ewing Hall, Department of Mathematical Sciences, University of Delaware, Newark, DE 19716, and **Rachael M. Todd** (todd@math.udel.edu), 114 Ewing Hall, Department of Mathematical Sciences, University of Delaware, Newark, DE 19716. *Beginning Behind: The Effect of Background Knowledge and Mathematical Self Image on University Precalculus Students' Success.*

The issue of successfully preparing future STEM majors is important for both the intellectual and financial well-being of the United States. Most students who declare one of these majors were "good in math" in high school. However, to the majority, "doing mathematics" means solving problems that involve a specific procedure or strategy. While they engaged in "problem solving," few of these problems could be described as mathematical explorations or required students to reflect on their learning. For this reason, many students end up re-taking mathematics courses at the university. This presentation will describe the emerging mathematical understanding of students in a university precalculus course intended for STEM majors. Based on the results of a pretest and survey administered at the beginning of the course and subsequent evaluations during the semester, we will describe how students' background knowledge (conceptual and procedural) and view of themselves as a student of mathematics contributed to their success in the course. Thus, given the pervasiveness of this issue, special care should be provided to help students bridge-the-gap between high school and university-level mathematics. This study will provide both research results and practical solutions for this alignment. (Received September 18, 2009)

1056-D1-941 **Jeffery D. Sykes*** (sykesj@obu.edu), Dept of Mathematics and Computer Science, Ouachita Baptist University, 410 Ouachita Street, Arkadelphia, AR 71998. *An alternative to intermediate algebra for liberal arts majors.* Preliminary report.

Many college students now take general studies mathematics courses that focus on appreciation of mathematics and quantitative reasoning skills. Many of these courses maintain the level of rigor of a college algebra course, but choose to cover historical, applied, and discrete topics that do not require mastery of algebraic skills. The traditional developmental mathematics curriculum, on the other hand, is designed to echo the algebra-focused high school curriculum that prepares a student for college algebra and eventually calculus. Is this the best approach to developmental coursework for students bound for these newer breed of general studies courses?

The author has been involved in the design of a new developmental mathematics course at the level of intermediate algebra, but focusing on problem-solving techniques instead of the mastery of algebraic skills. This course is intended to prepare students for success in a quantitative reasoning course that does not require algebraic mastery. The author will discuss the design of the course, implementation issues, and preliminary results from the course's first set of students. (Received September 18, 2009)

1056-D1-1150 **Álvaro Lozano-Robledo*** (alozano@math.uconn.edu), Department of Mathematics, 196 Auditorium Road, University of Connecticut, U-3009, Storrs, CT 06269, and **Tom Roby** (troby@math.uconn.edu). *The Quantitative Learning Center at UConn, and the effects of online homework in the study habits of students.* Preliminary report.

The University of Connecticut's Quantitative Learning Center (Q Center) is a resource to elevate the proficiency of students taking quantitative intensive courses across the undergraduate curriculum. We provide direct assistance to students via peer tutoring, review sessions, and the creation of innovative learning tools. In this talk, we will describe how the Q Center is helping students transition from their high school math into their first college-level mathematics courses, with the help of our tutors. We will also discuss how the data collected at the Q Center can provide very important live feedback for academic departments. As an example, we will discuss the effects of online homework in the study habits of our students, which we have been tracking before and after the web-based system was introduced. (Received September 21, 2009)

1056-D1-1321 **Frank Anthony Cerreto*** (Frank.Cerreto@stockton.edu), The Richard Stockton College of NJ, Jim Leeds Road, Pomona, NJ 08240. *Developmental Mathematics Program Assessment: A Case Study.* Preliminary report.

For over 30 years, colleges and universities have offered developmental mathematics programs for underprepared students. However, efforts to evaluate the efficacy of these programs have been sporadic. During the past two years, the Richard Stockton College of NJ has developed and implemented a robust, long-term assessment plan for its developmental mathematics program, passing through the following stages: setting goals, defining objectives, establishing expected student outcomes, collecting data, analyzing results, drawing conclusions, and planning for further assessment. The assessment program covers both the cognitive and the affective domains.

This paper describes the process used to develop and conduct the assessment program, early results, and lessons learned. (Received September 21, 2009)

1056-D1-1332 **Lipika Deka*** (ldeka@csumb.edu), Chapman Science Academic Cemter, Department of Mathematics & Statistics, 100 campus center, Seaside, CA 93955. *A successful model for teaching developmental math at CSU-Monterey bay.*

Developmental Math or Math remediation has been one of the most challenging issues at California State Universities(CSU). On an average 45%-65% of the freshmen coming to any CSU campus require remediation. For example at CSU-Monterey Bay about 55% of Freshmen needed remediation for last couple of years. The key to having a successful retention of the freshmen is to have high passing percent of the remediation class. The remediation models used in the passed at CSUMB has not been very successful with a passing percentage of 60% or less. But our new redesigned model which has been used since Fall 2007 has been a great success with a passing percent of 85% or more. One of our key components of this model is to keep track of each of our students' progress every week with individual communication done in class and outside class by email. In this talk we will discuss our model and its challenges. We are trying to see if this kind of a model could be an answer to having successful remediation program at CSU. (Received September 21, 2009)

1056-D1-1413 **Suzanne Galayda*** (sgalayda@nmsu.edu) and **Kathleen Berver**. *Online Interdisciplinary Mathematics: Project MESH.*

Project MESH (Mathematics, Engineering, Science Hybrids), is a New Mexico State University program funded by the Minority Science and Engineering Improvement Program. This U.S. Department of Education program assists predominantly minority institutions in effecting long-range improvement in science and engineering education programs and increasing the flow of underrepresented ethnic minorities, particularly minority women, into science and engineering careers. Project MESH approached these goals in three ways: Summer Institutes, Web-based Courses, and Calculus Umbrella Sections. This presentation will discuss the development and implementation of the web-based courses. We will cover the tools used to develop and present mathematics online. Additionally we will discuss challenges encountered in the presentation of these courses during the past academic year. (Received September 21, 2009)

1056-D1-1778 **William O. Bond*** (bond@math.uab.edu), Dept. of Mathematics, University of Alabama at Birmingham, Birmingham, AL 35294-1170, and **John C. Mayer**. *Blending Inquiry-Based Class Sessions with Computer-Assisted Instruction.* Preliminary report.

Student success as measured by grades, and greater efficiency in terms of cost effectiveness, have been a driving force in "course reform" over the past 15 years. One prevalent direction of course reform has been the development of sophisticated computer-assisted instruction. This approach has often been applied to large-enrollment developmental courses in mathematics. In an experiment conducted in Fall, 2009, we compare the effect of incorporating inquiry-based group work 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 group work sessions differentially benefit students in terms of mathematical self-efficacy, content knowledge, problem-solving, and communications. As a secondary effect, we hypothesize that such students will have greater success in subsequent algebra courses. In our experiment, all students receive the same computer-assisted instruction component. Students are randomly assigned to a treatment (group work or lecture). Measures, including pre- and post-tests, are described. Statistically significant differences have previously been observed in a similar study of multiple sections of a Finite Mathematics course in Fall, 2008. (Received September 22, 2009)

1056-D1-1821 **Mary R Parker*** (mparker@austincc.edu), Austin Community College, Northridge Campus, 11928 Stonehollow Drive, Austin, TX 78758. *Preparing students for Elementary Statistics or Math for Liberal Arts.* Preliminary report.

What habits of mind and mathematical skills are needed to prepare students for elementary statistics courses and math for liberal arts courses? Where do the students learn those skills? Should we have a different developmental math course to prepare for these courses? Austin Community College has addressed these questions by developing a separate course with an Elementary Algebra prerequisite. I'll describe the course, the students, and some of the challenges and successes. (Received September 22, 2009)

1056-D1-2061 **Paul R. Coe*** (coepaul@dom.edu), 7900 W. Division Street, River Forest, IL 60305. *Transitions: Helping Under-Prepared Students Find Success at Dominican University.*

For more than a dozen years, Dominican University has had a program in place to recruit, enroll, and support motivated students who don't meet the university's traditional admissions requirements. The program has evolved over time and is currently called Transitions. In my paper I will describe the students that we recruit, how we recruit them, and how we support them once they are on our campus.

Dominican University is located in River Forest, Illinois, a suburb of Chicago about 14 miles from the city center. Most of our applicants come from metropolitan Chicago, many from good suburban school districts, but some from city and suburban schools that generally under-prepare their students for college. Our Transitions program seeks to identify students with the desire and ability to succeed in college whose test scores might otherwise keep them from admission. We help prepare them for college with a five-week summer program in math and English, and we support them during the school year with advising, mentoring, tutoring, and participating in the Dominican community. In my presentation I will outline our summer program, describe the support that we provide these students during the school year, and present data on their retention and graduation rates. (Received September 23, 2009)

# *Engaging Students with Classroom Voting*

1056-E1-268 **Kimberly Jordan Burch***, 210 South 10th St., Indiana, PA 15705. *Clickers in the Classroom.*

A study was conducted over three semesters investigating the effectiveness of classroom response systems, commonly called "clickers". Of particular interest to the investigator was whether using clickers would improve the understanding and retention of material better than traditional lecture techniques. The study was conducted in a non-majors mathematics survey course. For the first exam, select topics were taught to one class with slides using clicker technology while the other class was taught the same topics using traditional lecture techniques. The two classes alternated roles every subsequent exam. The scores on the exam questions pertaining to these topics for each class were recorded. Certain mathematical topics showed statistically significant higher exam scores when taught with clickers versus traditional lecture methods. Student interaction and feedback about the clickers was positive. Classroom discussions ensuing from re-polling questions were often extensive as students argued for their answer choice. An analysis of the findings and conclusions will be presented. (Received August 23, 2009)

1056-E1-279 **Ron Buckmire*** (ron@oxy.edu), Fowler 313, Mathematics Department, Occidental College, 1600 Campus Road, Los Angeles, CA 90041. *Use of Classroom Voting In Liberal Arts College Classes (Small and Large).* Preliminary report.

A preliminary report will be given on the use of classroom voting (via electronic personal response systems) in small (under 20 students) and large (over 35 students) classes at a liberal arts college. The courses in which the author has used "clickers" range from calculus, linear algebra, differential equations and a summer program for entering first-year students. Implementation details, experiential observations and suggestions for improvement will be offered. (Received August 24, 2009)

1056-E1-414 **Herle M. McGowan*** (mcgowan@stat.ncsu.edu), Department of Statistics, North Carolina State University, Box 8203, Raleigh, NC 27695-8203, and **Brenda K. Gunderson** and **Vijay N. Nair**. *A randomized experiment exploring features of clicker use and their impact on undergraduate students' engagement and learning in statistics.*

This paper describes a randomized experiment conducted in an undergraduate introductory statistics course that investigated the impact of clickers on students. Specifically, the effects of three features of clicker use on engagement and learning were explored. These features included: 1) the number of questions asked during a class period, 2) the way those questions were incorporated into the material, and 3) the grading or monitoring of clicker use. Several hierarchical linear models of both engagement and learning outcomes were fit. Based on these analyses, there was little evidence that clicker use increased students' engagement. There was some evidence, however, that clicker use improved students' learning. Increases in learning seemed to take place when the clicker questions were well incorporated into the material, particularly if the number of questions asked was low. (Received September 04, 2009)

1056-E1-618 **Tami K. Dashley*** (tkdashley@miners.utep.edu). *Using Classroom Voting to Address Students' Probability Misconceptions.*

Students often have misconceptions in their probabilistic reasoning. One such misconception is the overuse of the representativeness heuristic, in which one determines that one event is more likely than another event based on how representative the event is of some aspect of its parent population. A research study was conducted to address high school students' overuse of the representativeness heuristic using three groups: (i) a prediction-and-voting group in which students were taught a lesson on probability with the use of prediction and classroom voting teaching methods, (ii) a prediction-only group where students were taught the lesson using only prediction, and (iii) a comparison group in which students were taught without the use of prediction or classroom voting. Analysis of pre- and post-test data indicates that while all three student groups showed improvement in their use of the representativeness heuristic; the prediction-and-voting group was the only group that did not show a tendency to always answer "equally likely" to probabilistic problems. This indicates that prediction and classroom-voting teaching methods might foster deeper levels of thinking and improved judgment in students, as opposed to indiscriminately applying newly learned ideas. (Received September 14, 2009)

1056-E1-682 **Travis K Miller*** (tkmiller@millersville.edu), Department of Mathematics, Millersville University, P.O. Box 1002, Millersville, PA 17551. *Preservice Elementary Teachers' Perceptions of Clicker Use in their College Mathematics Course.*

This presentation centers on an implementation of clickers in a mathematics content course for preservice elementary teachers. The voting technology was employed using an answer-discuss-answer format in which students answered questions individually, discussed the concepts in small groups, and then re-answered as a preliminary stage to class-wide exploration and formalization of the mathematical content. A second section of the course with the same instructor did not use clickers, instead relying on more traditional teaching strategies.

Written feedback was gathered from the preservice elementary teachers in both classes to gain insight into their perceptions of the academic benefits of clicker use. Most students using clickers expressed positive perceptions of the voting technology, and they shared significantly more favorable views than those who did not use clickers in their course. Members of the class using the voting technology noted a variety of reasons why they felt the inclusion of clickers helped them to better learn and understand course material. Many students were able to identify at least one mathematical topic for which they felt clicker use led to improved personal understanding. (Received September 15, 2009)

1056-E1-1053 **L Pedro Poitevin*** (lpoitevin@salemstate.edu), 352 Lafayette Street, Salem, MA 01970. *Classroom voting in an introductory real analysis course.*

Inspired by Guershon Harel's call to pay attention to "intellectual need" in the introduction of mathematical concepts, I have attempted to motivate specific important concepts in real analysis by generating questions that reveal to students the utility of said concepts prior to their introduction. In this talk, I will discuss how I have integrated classroom voting in the setting of an introductory real analysis course. I will pay special attention to questions that have either revealed student misconceptions or generated interesting peer discussions in the classroom. (Received September 20, 2009)

1056-E1-1248 **Patti Frazer Lock*** (plock@stlawu.edu), Dept of Math, CS, and Statistics, St. Lawrence University, Canton, NY 13617. *Using Clickers in Advanced Undergraduate Mathematics Courses.*

The speaker will discuss the use of a personal response system (clickers) in upper-level math courses. Specific outcomes from using classroom voting will be discussed, including student satisfaction, classroom dynamics, and learning, with a focus on learning how to write valid proofs. The speaker will discuss the impact and give examples from a 300-level Group Theory course, a 300-level Graph Theory course, and a 200-level Bridge to Higher Math course. (Received September 21, 2009)

1056-E1-1348 **Janet A White*** (jwhite@millersville.edu), Mathematics Department, Millersville University of PA, PO Box 1002, Millersville, PA 17551. *Utilizing Personal Response Systems (Clickers) in Liberal Arts Mathematics Courses to Support a Lecture Format.* Preliminary report.

This session continues the examination of a research project involving Personal Response Systems (PRS) in undergraduate mathematics classes. Thus far the study has examined the use of PRS in small classes (about thirty) for elementary education majors to elicit greater class participation and discussion. This stage of the project seeks to see if the same format (question, discussion, and repeat question) can be successful in a very different setting. It involved collecting data from two sections of students in a mathematics survey course, which is a liberal arts mathematics course for non-science/mathematics majors. The classes each had about seventy-five students and were taught in an auditorium "lecture style" classroom. This presentation will provide participants with a through a description of the usage of the PRS on a regular basis, as well as the perceived impact on student participation and learning based on the professor's observations, on students' frequency of participation, and demonstrated growth on content knowledge (when applicable). Additional time will be spent during the presentation to discuss generalized issues, concerns, and challenges, as well as data from the students regarding their perception of the value of the PRS in the class. (Received September 21, 2009)

1056-E1-1619 **M. McGivney-Burelle Jean*** (burelle@hartford.edu), 200 Bloomfield Avenue, Mathematics Department, West Hartford, CT 06117. *Classroom Voting: Using Students' Responses to Write Better Questions.*

For the past 3 years we have taught our math for liberal arts course at the University of Hartford using classroom voting pedagogy supported by student response systems (i.e., "clickers"). In the short time we have used clickers, we have found them to have a positive impact on promoting active student engagement in class, encouraging participation from all students, and creating a safe space for shy and uncertain students to participate in class. The use of clickers has also allowed us to instantly gauge the general understanding of the class and take appropriate mid-course corrective action when students do not understand a particular concept or problem. Most recently we have begun collecting data on students' responses to the questions we pose during class. Using these data we are able to write better questions–that is, questions that encourage more deliberation and discussion and result in more horizontal and less vertical bar graphs of responses. In this talk I will provide examples of questions and related student response data. (Received September 22, 2009)

1056-E1-1759 **Kim Roth*** (roth@juniata.edu), Brumbaugh Academic Center, 1700 Moore Street, Huntindon, PA 16652, and **Lynn Cockett**, Brumbaugh Academic Center, 1700 Moore Street, Huntingdon, PA 16652. *Clicker examples versus board examples in Calculus: how are they different?*

We examined videotaped Calculus 1 lectures and examined how clicker examples differ from board examples in length, wait-time length, and teacher immediacy behaviors.

In the fall of 2008 Kim taught two sections of Calculus I. Each section used clickers daily, always for a warm-up question and usually for several questions during lecture. The students see the warm-up question when they arrive in the classroom and the question is discussed after 10 to 15 minutes of homework questions. The clicker questions during lecture follow the format of answer, pair and share, answer again, and the discuss as a whole.

For each exam Kim picked two topics that had clicker questions associated with them. In one section clicker questions were used for those examples and in the other section board examples were done except for the warm-up clicker question on the previous day's material. The sections were reversed for the other topic. Each particular class day was videotaped and had related questions on the in-class exams and the final. We will look specifically at the videotapes and what they tell us about clicker and board examples effectiveness. (Received September 22, 2009)

1056-E1-1985 **Erick B Hofacker*** (Erick.B.Hofacker@uwrf.edu), 214C North Hall, River Falls, WI 54022, and **Kay Shager** (n.kay.shager@uwrf.edu), 206D North Hall, River Falls, WI 54022. *Using Clickers in a Refocused College Algebra Course – Part I.*

This is the first of two papers which describes how a cohort of instructors chose to incorporate clickers into a refocused college algebra course. Since it is a refocused course, the main emphasis is placed on conceptual understanding, modeling, and real-life application of algebraic topics. Skills and computation are still incorporated into the course, but they aren't the main emphasis. Thus clickers proved to be a great tool for gaining instantaneous feedback from students to better understand how they understand the concepts of the course.

In each section the clicker questions were integrated into the daily lessons so they overlapped with the examples from the lecture, as well as with the problems students solved during class. Example clicker items will be shared with the audience. The authors will describe similarities and slight differences between their uses of the clickers within their own section of the course. They will each describe their own method for incorporating clickers into daily class activities, and how they were used to encourage student discussion within peer groups, to challenge their thinking, and correct potential misconceptions. The authors will discuss the observed effects the use of clickers had on their students during the course. (Received September 22, 2009)

1056-E1-2009 **Sherrie J Serros*** (serrossj@uwec.edu), Department of Mathematics, University of Wisconsin - Eau Claire, Hibbard Hall 502, Eau Claire, WI 54702, and **Kathryn T Ernie** and **Erick B Hofacker**. *Using Classroom Response Systems in Mathematics to Facilitate Discourse, Reasoning, and Representations in the Development of Mathematical Content Teacher Knowledge.*

Using classroom voting in content courses and workshops for teachers provides new avenues for encouraging classroom engagement. Over the past two years, our methods of infusing classroom voting have evolved from single item concept checks with discussion about mathematics to an integrated series of questions that more deeply probe conceptual understanding and that foster reasoning and the development of student representations.

Discussions of options in well-developed voting questions provides the opportunity to expand the mathematical conversation into common student misconceptions, ones that teachers may encounter in their future teaching. These experiences are developing mathematical content teacher knowledge that goes beyond the mathematics concepts themselves. Multiple series of clicker items and students' responses will be shared during this session. (Received September 22, 2009)

# *Experiences that Enrich the Education of Mathematics Majors*

1056-E5-97 **Faun C. C. Doherty*** (fdoherty@washjeff.edu). *An undergraduate original research experience: Mathematical modeling with graph theory.*

Entering the research arena in graduate school can be an intimidating idea to undergraduate math majors who have little to no experience doing original research. With a grant from the Howard Hughes Medical Institute, I was able to conduct an internship in mathematical modeling with three math majors at Washington and Jefferson College during the summer of 2009. This experience proved to be outstanding both for me as a mentor, and for the students involved. The subject was to explore some mathematical models used in DNA sequencing. Not only were the students required to learn the biology, and work within an interdisciplinary setting, but they were able to develop and prove their own result. I will describe our journey into original research, the students reactions to it, and the benefits that such a program has for students who are considering what it really is like to do independent math research. (Received August 27, 2009)

1056-E5-211 **David A. Brown*** (dabrown@ithaca.edu), Ithaca College, Dept of Mathematics, 953 Danby Road, Ithaca, NY 14850-7000. *From Inquiry to Research - Fostering Research with Undergraduates.*

The Mathematics Department at Ithaca College has maintained a research course sequence for several years. Recently, we added a first year inquiry based course, *Mathematical Experimentation*, to introduce students to the nature of experimentation and conjecture/proof in mathematics. This course, along with a second year course, *Sophomore Seminar*, prepares students for the junior level research sequence of *Junior Seminar* and *Research Experience in Mathematics*. We will discuss the impact of this inquiry-based approach on the majors (and non-majors.) We also highlight future changes in the senior year that will provide a conclusion to the research efforts in the first three years. (Received August 15, 2009)

1056-E5-246 **Kris Kappmeyer**, **Sarah Minerva Venuti**, **Courtney Marie Chancellor** and **Padmanabhan Seshaiyer*** (pseshaiy@gmu.edu), 4400, University Drive, MS: 3F2, Department of Mathematical Sciences, George Mason University, Fairfax, VA 22030. *Enhancing teaching and learning of undergraduate mathematics majors through transformative research and training in biological and bio-inspired systems.* Preliminary report.

In this work we share our experiences from a multidisciplinary undergraduate research program in mathematical and computational 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 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 August 19, 2009)

1056-E5-263 **Suzanne Lenhart*** (lenhart@math.utk.edu), University of Tennessee, Dept of Math, 104 Aconda Court, Knoxville, TN 37996-0612, and **Sarah Duncan**, NIMBioS, University of Tennessee, 1534 White Ave. Suite 400, Knoxville, TN 37996-1527. *REU and REV program at the new institute, NIMBioS.* Preliminary report.

The National Institute for Mathematical and Biological Synthesis hosted its first summer research program for undergraduates in 2009. Math majors and biology majors worked together in teams on problems at the interface of the two fields. This talk will discuss various features of this program, including having four veterinary students and two high school teachers as participants. The term REV stands for research experiences for veterinary students. (Received August 21, 2009)

1056-E5-266 **Michael E McDaniel*** (mcdanmic@aquinas.edu), 1607 Robinson Road SE, Grand Rapids, MI 49506. *Undergraduate Research as Resource.* Preliminary report.

At Aquinas College, a small 4-year school, we have deveolped undergraduate research opportunities which have influenced our department's programs. Connecting our students' research with the Math Club, course modifications, assessment, and acreditation has strengthened our department. In this talk, we will examine our model's evolution. (Received August 23, 2009)

1056-E5-480 **Barbara P. Gonzalez-Arevalo*** (bgonzalez@roosevelt.edu), Dept. of Mathematics and Actuarial Science, Roosevelt University, 430 S Michigan Ave, Chicago, IL 60605, and **Melanie Pivarski** (mpivarski@roosevelt.edu), Dept. of Mathematics and Actuarial Science, Roosevelt University, 430 S Michigan Ave, Chicago, IL 60605. *Integrating Civic Engagement in an Integral Calculus Course.* Preliminary report.

Roosevelt University is a national leader in educating socially conscious citizens for active and dedicated lives as leaders in their professions and their communities. Therefore, we will redesign the Calculus II course (Integral Calculus) to include a civic engagement component.

After successfully completing this course the students will be able to apply Integral Calculus concepts and methods to model "real-world" problems that have a social impact in their community or in the world at large. They will also be able to get answers to specific questions using their model, and they will learn how to use these answers to impact society. Beyond the capacity to solve mathematical problems, they will be able to communicate their findings clearly, both verbally and in writing, and to explain the mathematical reasoning behind their conclusions.

The class will participate in a semester-long group project involving social issues. The students will work in groups of 2 or 3 students. The end result will be a written report and an oral report of their mathematical findings and a plan to disseminate the results to a wider audience. For the projects we will create a partnership with the Education Department at the Shedd Aquarium in Chicago. (Received September 09, 2009)

1056-E5-561 **Katarzyna Potocka*** (kpotocka@ramapo.edu), School of TAS, Ramapo College of New Jersey, 505 Ramapo Valley Road, Mahwah, NJ 07430. *Enriching the education of mathematics majors with career seminars, undergraduate student research, and student events at MAA sectional meetings.* Preliminary report.

This paper presents the author's contributions to enriching the education of mathematics majors beyond the standard curriculum at Ramapo College. In order to address the commonly asked student question "What can I do with a degree in mathematics besides teaching?", the author, as a co-advisor of the math club, jointly with another faculty member developed a successful series of career seminars. Some of the recent seminars include talks by a senior-level actuary, a Wall Street analyst, and a mathematician from Google, presentations about graduate schools and about other industries hiring mathematics majors, with some of the speakers being alumni of the college. In this presentation, the author shares her experiences of organizing such seminars. Moreover, the author will describe her work on conducting mathematics research with undergraduates. The author's recommendations for the Experiential Component of a course in mathematics (done outside of a classroom) will be discussed as well. The author will also present her experiences and recommendations on organizing well-attended student events at MAA sectional meetings. (Received September 12, 2009)

1056-E5-573 **Sharon S. Emerson-Stonnell*** (emersonstonnellss@longwood.edu), Sharon Emerson-Stonnell, Mathematics Department, Longwood University, Farmville, VA 23960. *Combining Mathematics History with a Greece Tour.* Preliminary report.

A three-credit junior level mathematics history course was combined with a twelve day tour of Greece. The course began during the spring semester in January 2009 and concluded in the first summer session in June 2009. Two-thirds of the course was taught during the spring semester on campus. The campus portion included Egyptian, Greek, Chinese, Indian, Islamic, and European mathematics up to the beginnings of calculus. Emphasis was on the areas of geometry, algebra, and calculus. The campus portion involved readings, discussions, lectures, student presentations, and some activities. The final third took place during the Greece tour. The class of eight students traveled with groups from four other universities during the tour. The course portion during the tour emphasized the work of Greek mathematicians and their influence in ancient and modern times. This portion was heavily dependent on student interaction, including presentations, discussions, activities, and included some lectures. This presentation will include the development of the course and tour, enrichment through travel, and anticdotal evidence of renewed student excitement about mathematics. Preliminary report. (Received September 13, 2009)

1056-E5-763 **Joyati Debnath*** (jdebnath@winona.edu), Mathematics & Statistics, 304 Gildemeister Hall, Winona, MN 55987. *Expanding Opportunities in Mathematics across the Curriculum.*

This presentation will discuss various activities implemented in the mathematics department of Winona State University to create an environment for mathematical understanding across the entire spectrum of the curriculum. The activities include offering an upper level research based Mathematical Thinking course for the mathematics majors, the Distinguished Lecture Series in Mathematics, Colloquium Series, establishing Mathematics Achievement Center and giving students experience for attending and presenting at the regional and national mathematics meetings. Moreover, a grant writing experience for creating a scholarship program in mathematics to improve educational opportunities for academically talented and financially needy students, will be discussed. (Received September 16, 2009)

1056-E5-1164 **Jeffrey L Poet*** (poet@missouriwestern.edu), Missouri Western State University, 4525 Downs Drive, Saint Joseph, MO 64507, and **Laurie J Heyer**, Davidson, NC. *Collaborative Synthetic Biology Research for Undergraduates.*

Missouri Western State University and Davidson College have an active collaborative undergraduate research program in the area of synthetic biology. For four years, a combined team of undergraduate biology and mathematics majors from the two institutions, under the direction of a faculty mentoring team of one mathematician and one biologist from each institution, have worked together on synthetic biology projects related to bacterial computing. This talk will briefly describe the structure of our research program and a few of the interesting contributions of the mathematics majors to our interdisciplinary research goals. (Received September 21, 2009)

1056-E5-1200 **Michael Dorff*** (mdorff@math.byu.edu), Department of Mathematics, Brigham Young University, Provo, UT 84602. *"Introduction to Being a Math Major" seminar.*

We will discuss our "Introduction to Being a Math Major" seminar which this fall semester has 85 students enrolled in it. The seminar for beginning math majors at Brigham Young University discusses: (a) scholarships, undergraduate research, departmental activities, and summer programs available to math majors; (b) some current research ideas in mathematics; (c) the culture of mathematics; and (d) career options available to math majors. For the career options, we invite 4-5 guest speakers who have a degree in mathematics and who work in a non-teaching career (e.g., lawyer, medical doctor, operations researcher, actuary, NSA employee, etc.). These speakers spend 45 minutes talking about these careers and how mathematics has helped them in these careers. These talks are open to all students and are very popular with the average attendance being about 150 people. (Received September 21, 2009)

1056-E5-1603 **Deborah Lawrence*** (lawred@sage.edu), Department of Mathematics, 45 Ferry Street, Troy, NY 12180, and **Tina Alves Mancuso** (mancut@sage.edu), Department of Mathematics, 140 New Scotland Avenue, Albany, NY 12208. *Enriching the Major through a Comprehensive Scholarship Program.* Preliminary report.

The Sage Colleges conducts a program called Scholarships In Mathematics, Engineering, and The Sciences (SIMETS), funded by the National Science Foundation. (See http://www.sage.edu/academics/mathandcomputingsciences/resources/simets/.) This program is modeled after our previously successful NSF-funded program Scholarships In Mathematics And Computer Science (SIMACS). The authors will present details of the program's components, which include: scholarship money, funds toward the purchase of a laptop, mentoring, tutoring, field trips and site visits. We will discuss how this program has served to enrich the undergraduate experiences of the SIMETS scholars, as well as the impact it has had on enrollments. (Received September 22, 2009)

1056-E5-1708 **Diana White*** (diana.white@ucdenver.edu), University of Colorado Denver, Campus Box 170, P.O. Box 173364, Denver, CO 80217-3364. *Engaging math majors in education research.*

In this talk, we discuss a Research Experience for Undergraduate math majors in mathematics education research. As part of an NSF supplement to the Rocky Mountain Middle School Math-Science Partnership (RM-MSMSP), the author has involved two math majors in an education research project. The project involves social network surveys of all RM-MSMSP teachers, as well as every middle school in a local school district. The students were involved in every level of the project, from survey design and administration, to data analysis and writing of a research report. Additionally, social network analysis involves mathematical knowledge from graph theory as well as statistical analysis, thereby connecting topics from the math major to educational research. (Received September 22, 2009)

1056-E5-1979 **G. Daniel Callon*** (dcallon@franklincollege.edu), Franklin College, 101 Branigin Boulevard, Franklin, IN 46131. *Creating a Departmental Culture of Enriching Experiences.*

The Department of Mathematics and Computing at Franklin College has constructed an integrated experience for its mathematics majors and minors featuring innovative courses and co-curricular programming whose purpose is to help its students learn about the professional opportunities available in mathematics in keeping with Franklin's mission and the composition of its student body with 35-40% first generation college students.

The courses include a one-hour freshman activity course which introduces students to professional opportunities in mathematics and emphasizes mathematical processes and ways of working, and a junior-senior level semester-long team statistical consulting service project for a local non-profit agency.

Co-curricular programming incorporates interaction with fellow students, faculty, alumni, and other professionals.

On our campus of 1040 students, the number of mathematics majors and minors is growing substantially (currently about 15 sophomores have declared majors in mathematics) and attendance at departmental events runs between 35 and 60.

This presentation will provide details about the courses and programming as well as tips for putting together such a program on your own campus. (Received September 22, 2009)

1056-E5-2016 **Urmi Ghosh-Dastidar*** (ughosh-dastidar@citytech.cuny.edu), Namm 711 (Mathematics Department), 300 Jay St., Brooklyn, NY 11201. *Bio-Math Connection in Undergraduate Mathematics.* Preliminary report.

In this presentation the author intends to talk how various topics in Biology is implemented in a regular Mathematics classroom and also beyond classroom environment. The author will provide some interesting classroom examples that were used to improve students' critical thinking skills and elevate students' engagement. (Received September 22, 2009)

# How Assessment Results Changed Our Program

1056-F1-443 **Jacqueline M Dewar*** (jdewar@lmu.edu), Loyola Marymount University - Dept of Math, 1 LMU Drive - UH 2700, Los Angeles, CA 90045. *Using a knowledge survey for course and program level assessment in mathematics.*

This talk will describe the use of an assessment tool known as a knowledge survey to (1) measure content learning in a quantitative literacy course, and (2) examine student learning outcomes across a three-semester calculus sequence. This assessment instrument deserves wider consideration because it is relatively easy to construct, is quicker and can be more comprehensive than actual pre/post testing, and produces end results that Nuhfer and Knipp (2003) claim to correlate well with performance on final exams. Although biologists Bowers, Brandon and Hill (2005) have questioned the validity of knowledge surveys as a measure of student learning, the author's experience with them seems to corroborate claims of their ease of construction, savings in time, and production of results for program level assessment similar to those found by examining final exams. This presentation will also describe changes made to the QL and calculus courses and time saved in department level assessment efforts as a result of using knowledge surveys. (Received September 07, 2009)

1056-F1-557 **Vesna Kilibarda*** (vkilibar@iun.edu), Department of Mathematics and Actuarial Sc., Indiana University Northwest, 3400 Broadway, Gary, IN 46408. *Assessment of Mathematical Reasoning Courses for Business Students and Liberal Arts Students.*

Several years ago, our department was faced with declining students success in general education courses. The DFW rate in Finite Math course was especially worrying our colleagues in the Business School, since it was detrimental to their accreditation. The class for Liberal Arts became a requirement for several health fields, including nursing and needed adjustment to the enlarged student population it serves. The time was right for a change, and our approach toward improvement was multifaceted. First we started enforcing prerequisites. Only those students who took the prerequisite course or have passed the appropriate pretests could take the next math course. We published practice pretests and enabled students to be tested after practice. We had discussions with colleagues from schools whose students the courses were serving. Based on this feedback, we changed emphasis on certain topics in our courses. Handouts were developed for topics that needed special treatment. We created common midterm and final exams that assess appropriate outcomes. Based on the analysis of random samples of these exams we continue to make necessary changes in the courses. In the talk we will show how the changes we implemented resulted in improvement in student performance and satisfaction. (Received September 12, 2009)

1056-F1-637 **Harrison W. Straley*** (straley_harrison@wheatonma.edu), Mathematics and Computer Science Dept., Wheaton College, 26 East Main Street, Norton, MA , and **Lauren Dupee** (dupee_lauren@wheatonma.edu), Mathematics and Computer Science Dept., Wheaton College, 26 East Main Street, Norton, MA 02766-2322. *The Impact of Pair Quizzes on Mathematics Achievement and Mathematics Attitude.*

Pair quizzes are short quizzes, covering course content, that are taken by a pair of students working together for a shared grade. Do these pair quizzes have any impact on student achievement in the mathematics course or on student attitudes toward mathematics? How does a student's pair quiz achievement correlate with their achievement in the course as a whole? The authors report on the "self-evaluations" of students in three college mathematics courses: Calculus II, Introductory Statistics, and Mathematics for Elementary Teachers; on achievement in and attitude toward mathematics. They also report on the correlation between pair quiz scores and final exam grades. (Received September 15, 2009)

1056-F1-900 **Jenn D Berg*** (jberg5@fsc.edu), 35 Miller Hall, 160 Pearl Street, Fitchburg, MA 01420. *An Assessment Loop (or How I Learned to Stop Worrying and love the Rubric).* Preliminary report.

We will discuss how the **program** level implementation of our assessment plan has affected **student** level performance. Our particular example follows the development of the rubric to be used in assessing the technology goal of our department's assessment plan. We will see how the development of this rubric has affected the Maple lab component of our Calculus 1 course (both how assignments are framed and the resulting improvement on students' work). (Received September 18, 2009)

1056-F1-1033 **J. Winston Crawley*** (jwcraw@ship.edu), Department of Mathematics, Shippensburg University, 1871 Old Main Drive, Shippensburg, PA 17257. *Assessment: If It Ain't Useful, Don't Do It.* Preliminary report.

The Department of Mathematics at Shippensburg University has been carrying out formal assessment, in a variety of settings, for more than ten years. This talk briefly describes our journey toward our somewhat irreverent credo which forms the title of the talk. The major emphasis of the talk, however, is on the loosely-constructed contrapositive of the title: *Assessment: If you do it, make it be useful.* We describe a variety of specific instances in which we have closed the loop, thus making formal assessment a useful effort. As a sidelight, we feature the university's adoption of the "five-column model" for assessment. (Received September 20, 2009)

1056-F1-1175 **Dick Jardine*** (rjardine@keene.edu), Mathematics Department, Keene State College, 229 Main Street MS2010, Keene, NH 03435-2010. *Faculty Development Through Assessment.* Preliminary report.

The recently implemented Integrative Studies Program (ISP) at Keene State College replaced a generation-old general education curriculum. The ISP is outcomes-based, and QL courses comprise one of the two foundations of the program. Initial assessment of student projects required in all QL courses indicated that students had significant difficulties in meeting program outcomes as measured by the locally-produced rubric used to evaluate the projects. The results of the assessment have been used to inform current and prospective faculty, and subsequent assessments have indicated improved results in percentages of students meeting program outcome standards. The assessment instrument and results will be presented, along with on-going and future implementations of recommendations to improve instructional practices. (Received September 21, 2009)

1056-F1-1308 **Miriam Harris-Botzum*** (mharrisbotzum@lccc.edu), 4525 Education Park Dr., Schnecksvillw, PA 18069. *Assessing Critical Thinking Throughout the Mathematics Curriculum.* Preliminary report.

Many colleges and universities list a set of competencies that must be addressed by every program, and presumably mastered by every student. Specific courses or course groupings in each program of study are supposed to address these competencies. For most non-STEM majors, the role of the mathematics requirement within the program is to address quantitative reasoning and critical thinking skills. How well are we doing our job in addressing these competencies? This year, our division decided to take a college-mandated requirement to assess one of these competencies and make it truly meaningful by creating critical thinking assessment tools for every course we offer, and administering them in every section of every course taught by our department. This paper is a look at the assessments we created, the preliminary results, and how the existence of these assessments has influenced teaching at our institution. (Received September 21, 2009)

1056-F1-1349 **Alison Ahlgren*** (aahlgren@illinois.edu), Department of Mathematics, 1409 W. Green Street, Urbana, IL 61801, and **Marc Harper** (marcharper@gmail.com), 601A Boyer Hall, Box 951569, UCLA, Los Angeles, CA 90095-1569. *Readiness Assessment and Course Placement through Introductory Calculus.*

The theory of knowledge and learning spaces is used to assess readiness and determine course placement for mathematics students at or below introductory calculus at the University of Illinois. Readiness assessment is determined by the artificially intelligent system ALEKS. The ALEKS-based mechanism from the University of Illinois reduces over-placement and is more effective than the former ACT-based mechanism. Significant enrollment distribution changes occurred as a result of the mechanism implementation. ALEKS assessments provide more specific skill information than the ACT. Correlations of ALEKS subscores with student maturity and performance meets expectations in many cases and revels interesting characteristics of the student population.

The data shows that preparation, as measured by ALEKS, correlates positively with course performance, more strongly than the ACT. Longitudinal comparison of students taking Precalculus shows that ALEKS assessments are an effective measure of knowledge increase. Calculus students with weaker skills can be brought to the skill level of their peers, as measured by ALEKS, by taking a preparatory course. The data is also used to measure course effectiveness and visualize the aggregate skills of student populations. (Received September 21, 2009)

# *Improving a Second Course in Statistics*

1056-F5-264 **Murray H Siegel*** (murray.siegel@asu.edu), 20159 N Geyser Dr, Maricopa, AZ 85138. *A Second Course for Non-Majors – Relevance is the Key!*

Experience in courses taught by the presenter give credence to the hypothesis that making statistics relevant to non-majors is key to success. The 1st example was the 2nd course in a sequence for MPA students. The program's comprehensive exam included an article from a sociological journal for which the students would analyze the statistical conclusions of the research. The course itself focused on multi-variate regression and ANOVA. The concepts and methods being taught were relevant to the students. There was no question about the importance of the various statistical methods. The second example was an independent study course developed at the request of a psychology major who had been in my introductory course. The course was designed to investigate experimental design and the meaning of inferential decision-making. For the 1st half of the course, the student would find research articles in appropriate psychology journals. Her assignment was to write abstracts for 12 articles and assess the appropriateness of the design and the research conclusions. The 2nd part of the course involved the writing of a research proposal for a psychological investigation, focusing on design and inferential methods. (Received August 22, 2009)

1056-F5-437 **Cora Neal*** (cora.neal@sonoma.edu), SSU Dept of Math and Stat, Darwin 114, 1801 East Cotati Ave, Rohnert Park, CA 94928. *Finding and Working with Real-World Clients in a Second Statistics Course.*

Sonoma State University has a popular minor in Applied Statistics that incorporates interactions with real-world clients. After some initial trepidation, I found that recruiting and working with clients was easy, rewarding, and beneficial to student understanding and appreciation of the power of statistics. I would like to share some ideas with you about how to find appropriate data sets for a project in a second course in statistics and how to structure and monitor student groups to help them work effectively and successfully. (Received September 07, 2009)

1056-F5-552 **Sue B Schou*** (schosue@isu.edu), P. O. Box 4043, Pocatello, ID 83205. *A Successful Second Course in Business Statistics.* Preliminary report.

Our second course in business statistics is required of all business majors and minors in the College of Business at Idaho State University. The course includes three major topics: regression, forecasting, and statistical process control. Students are required to come to class prepared to apply statistical principles to in-class activities designed to extend their knowledge. Chosen after attempting to teach this second course with Excel, Minitab plays a major role In student success. Most in-class activities involve working with real world data. Two major group projects that require gathering real business data from the Internet are completed by students with the first involving regression and the second, forecasting. In addition, each group must present the statistical results from one project as if to a business. Recently, we have dropped our final computer lab assessment due to excellent performance by students who have appropriately selected analysis, correctly applied the chosen statistical techniques, and written results well when supplied with a business scenario and associated data. (Received September 12, 2009)

1056-F5-617 **K. Scott Alberts*** (salberts@truman.edu), Truman State University, 100 E. Normal Street, Kirksville, MO 63501. *Experiential Learning of Non-parametric Statistics through a campus-client led survey project.*

Because campuses are always interested in opinion, and non-parametric statistics is closely tied to survey research, we offer a second statistics course built around a survey project for a local client. Clients are solicited with interest in a broad topic. A group of students is then assigned to work with each client to design, implement and report the survey and its results. Recent projects have examined campus technology, enrollment and retention, and improving student services. Clients include faculty, administrators, student government, and even the provost.

Classroom work focuses on theory, methods, techniques useful to the project, as well as the practical needs of real- world data. Students learn about many topics directly through the project. Universal concepts are covered early in the semester; supplemental concepts are covered just-in-time when needed by the project.

Students report deeper learning and a willingness to spend more time working on their projects. They are especially pleased that their work is useful and used. Clients report high levels of satisfaction and a willingness to make campus changes recommended by the project reports. Future goals for the course include soliciting nearby off-campus clients, such as local government entities or NGOs. (Received September 16, 2009)

1056-F5-1294 **Patricia B Humphrey*** (phumphre@georgiasouthern.edu), Department of Mathematical Sciences, PO Box 8093, Statesboro, GA 30460-8093. *Some More Lab Experiences in Introductory Statistics.*

For several years, I have used "lab" experiences in teaching Introduction to Statistics I, in which students collect or generate the data themselves. At Georgia Southern, we also have Introduction to Statistics II, which is taken by a few majors such as Information Technology, Political Science, International Studies, and Economics. From the list of majors who are required to take it, you can sense that this is a diverse group, and one in which many (most) really don't want to be in the course.

Over the past several years, I have attempted to use more active data collection and analysis in this course as a means of making the class more "real" as well as hoping to grab (and keep) student interest. To that end, I have devised several active lab experiences in the spirit of what I do in the first course. For example, we guess the number of jelly beans in jars for linear regression (and inference), measure the strength of facial tissues (two-sample t-test), and measure absorbency of paper towels (one-way analysis of variance).

This presentation will discuss the projects, how they were received by the students, and the successes and failures with my approach. (Received September 21, 2009)

1056-F5-1447 **Terje Hoim*** (thoim@fau.edu), 5353 Parkside Dr., Jupiter, FL 33458. *Interdisciplinary Case Studies for an Intermediate Statistics Course.*

We describe case studies in wildlife biology and new urbanism that introduce students to nonparametric tools and multiple regression. The goal of these studies is to drive a search for appropriate techniques, as opposed to introducing techniques and then searching for suitable applications. These case studies, which are developed from student and faculty research projects in the local community, help students make connections between the sciences and statistics, as well as strengthen college alliances with community partners. The hands-on approach provides opportunities for students to engage in the full process of designing and carrying out a research project as happens in practice, rather than in a text book, including sampling, data organization and entry, statistical analysis, and oral and written presentation of conclusions. (Received September 21, 2009)

1056-F5-1904 **John D McKenzie*** (mckenzie@babson.edu), Babson College, Mathematics and Science Division, 231 Forest Street, Babson Park, MA 02493-0310. *An Innovative Second Half-Course in Applied Statistics.*

This paper presents an innovative approach to expose upper-class students, mostly sophomores, to statistics beyond the topical coverage found in a well-designed first course in applied statistics. Applied Quantitative Modeling is a required three-credit course with approximately 50% of its coverage devoted to statistics. Namely, multiple linear regression and time series. It also covers three management science topics. Two of which, decision analysis and simulation, rely heavily on our first applied statistics course. Among the approved optional topics for the course is process control and total quality management. And, while an increasing number of our students waives out of our required three-credit Probability and Statistics course, almost none waive out of Applied Quantitative Modeling. This paper describes the statistical component of this course in detail. For example, its team mini-cases. It presents the benefits of a statistician teaching such a course with colleagues who are trained in mathematics and management science. It concludes with a discussion of recent changes in the course, especially how they impact its statistical component. (Received September 22, 2009)

1056-F5-1919 **Salil Kumar Das*** (DasSK@pgcc.edu), 1100 Mondrian Terrace, Silver Spring, MD 20904.
*Teaching Undergraduate Statistics in R.* Preliminary report.

R is a free, cooperatively developed, open-source implementation of the S statistical programming language and computing environment, a language that has become a standard among statisticians for the development of statistical software.

R is high quality software. Because it incorporates a true programming language S, R is command driven and relatively easily extended, an attractive characteristic for instructors, and for students in advanced classes. R runs on all of the commonly used computer platforms and installs in the normal manner on each platform.

It is easier in a command-driven system to correct, modify, and replicate analyses. It is simpler, and natural, to create a permanent record of one's work, including both input and output. R implicitly encourages a deeper understanding of the statistical procedures being used than do some other programs, such as SPSS and Minitab.

In this talk I will present some elementary commands in R to do basic statistics at the undergraduate level. I will demonstrate the efficacy of R as compared to other point-and-click GUI based statistical software packages.

The biggest reason to use R is the cost. It is free! (Received September 22, 2009)

1056-F5-2031 **Robin H Lock*** (rlock@stlawu.edu), Dept of Math, CS & Stat, St. Lawrence University, Canton, NY 13647. *Stat2 - What Should We Do?* Preliminary report.

We've paid much attention in recent years to improving instruction in introductory applied statistics courses. These efforts produce fewer students with the "worse course ever" reaction of the not too distant past and more who say "that was interesting, fun and even valuable – what's next"? While some disciplines have a well-established sequence of introductory courses, statistics has traditionally focused on just that first course, often leaving the follow up (and even the introduction) to various disciplinary methods courses. That might have sufficed in the days when few students wanted to continue beyond the first course, but (hopefully) those days are getting farther and farther behind us. We need a well-established curriculum and materials for a second course in statistics that will build on the ideas and enthusiasm generated in a good first course in order to attract students, including some of the 100,000+ students taking the AP Statistics exam each year, to further work in the discipline. A small group of statistics educators has been examining this issue for quite a few years and is (finally) putting together some ideas to share on how we might do Stat2. (Received September 22, 2009)

# *Innovative and Effective Ways to Teach Linear Algebra*

1056-G1-111 **Jen-Mei Chang*** (jchang9@csulb.edu), 1250 Bellflower Blvd., Department of Mathematics and Statistics, Long Beach, CA 90840-1001, and **Xuhui Li** (xli2@csulb.edu), 1250 Bellflower Blvd., Department of Mathematics and Statistics, Long Beach, CA 90840-1001. *Applying Image Processing Techniques to Promote Conceptual Understanding in Linear Algebra Classes.* Preliminary report.

The Intro to Linear Algebra at Long Beach State is traditionally populated with math and computer science majors. Recently, we have observed an increasing number of students from other disciplines partake in the course. These students are motivated by the intention to advance their collective knowledge in math through the learning of linear algebra. Inevitably, we are witnessing a pressing need to deliver innovative instructions that promote understandings of intellectually challenging concepts to a diverse audience. In this presentation, we will share a few image processing techniques that can be used in linear algebra instruction to illustrate difficult concepts such as vector subspace and orthogonal projection. In particular, we frontload the lessons with practical use of linear algebra ideas to increase students' interest level and offer a reference system for abstract concepts. This application-first, theory-second approach was shown to be effective in consolidating mental images and generating big pictures of difficult concepts. A favorable reaction was revealed by a mid-semester survey. Albeit a slight initial resistance, students were comfortable using some of the techniques learned in the class in solving real-life problems in the end-of-semester poster presentation. (Received July 27, 2009)

1056-G1-198 **Mark Anderson Miller*** (millerr@marietta.edu), Marietta College, Department of Mathematics & Computer Science, Marietta, OH 45750. *Matrices of Sequences: Recurrence and Computation.*

One difficulty in teaching a first course in linear algebra relates to examples. It can sometimes be difficult to come up with non-sparse matrices that are large enough to be interesting but still manageable for in-class computation of rank, eigenvalues, fundamental subspaces, etc.

In this note we consider families of matrices whose entries are successive members of well known sequences (e.g., Fibonacci). We examine ways in which recurrence identities can be used to simplify calculations when working with these matrices. Along the way we also consider ways in which software packages, such as *Mathematica*, can be used to hep us identify patterns when working with these matrices. In the end, we hope that such examples help students to see how one can use technology to gain insight and then use that insight to calculate results the old fashioned way: on a napkin with a pencil! (Received August 14, 2009)

1056-G1-237 **Paul Raymond Bouthellier*** (pbouthe@pitt.edu), 504 East Main Street, University of Pittsburgh-Titusville, Titusville, PA 16354. *Using Quaternions and Rotations Matrices for Rotations in R3.*

First we shall compare the methods of using quaternions and rotation matrices for implementing rotations. An object, such as a wireframe cube, will be rotated about its axes in R3, using first quaternions and then rotation matrices to compare the efficiency of the two methods.

Secondly we will use rotation matrices and quaternions to create a camera which will move through R3 and be allowed to rotate about its axes. The camera will allow the viewer to view a given scene from any position and orientation in R3. In creating such a camera, as quaternions can not deal with translations, movement through space will be accomplished via matrices and the rotations of the camera in space and about its axes with be accomplished be taking the product of the corresponding quaternions. Examples of all the concepts in this talk will be illustrated by interactive Flash programs. (Received August 18, 2009)

1056-G1-378 **Karsten Schmidt*** (kschmidt@fh-sm.de), Faculty of Business and Economics, Schmalkalden University of Applied Sciences, Blechhammer, 98574 Schmalkalden, Thuringia, Germany. *Enhancing Students' Attitudes towards Linear Algebra with Technology.*

When teaching linear algebra we have to deal with the following well-known problem: while the level of mathematical skills required to work with examples is generally low (students only need to add, subtract and multiply), the number of calculations is usually large. Therefore, working with examples is time-consuming and error-prone if done by hand. Students get tired quickly and lose interest in this increasingly important area of mathematics. The Schmalkalden University Faculty of Business and Economics therefore decided to move its introductory linear algebra course from the classroom to the PC lab, and purchased a Computer Algebra System license that also allows its use on the students' own PCs. A collection of functions was then developed to facilitate teaching by providing functions for the computation of zero matrices and vectors, matrices and vectors of ones, identity matrices, as well as idempotent and orthogonal matrices, "just-in-time", whenever they are needed during the course. Examples will show how beneficial it is, from the very basics to the more advanced topics, to sit in front of a PC in an introductory linear algebra course. (Received September 03, 2009)

1056-G1-411 **Murphy Waggoner*** (murphy.waggoner@simpson.edu), Indianola, IA. *Matrix Multiplication and Applications: A Chicken and Egg Problem.*

Which comes first: teaching matrix multiplication or teaching matrix applications? I will argue that applications come first.

I was teaching a mathematical modeling course without a linear algebra prerequisite, but I didn't want the students to miss out on modeling techniques like Leslie models and Markov chains. So, the students had to learn matrix multiplication, and they did so simultaneously while seeing the flow diagrams. The result was that these students understood the mechanism of matrix multiplication better than my linear algebra students who learned matrix multiplication as an abstract operation first and then studied applications later.

I will describe how matrix multiplication was presented in class, and how the comprehension of the students differed from that in a traditional linear algebra presentation. I will also show a game and some slides the students developed themselves to explain Leslie models and Markov chains and the matrix multiplication to other students. (Received September 04, 2009)

1056-G1-534 **Pamela G Coxson*** (coxson@speakeasy.net), 25 Fair Oaks Street, San Francisco, CA 94110. *Introducing Linear Algebra to Middle School Students.* Preliminary report.

A six week course of half hour sessions before school was used to introduce the ideas of linear algebra to middle school students. The course developed concepts in the context of two concrete examples: digital animation and dynamic population models. The course was not intended to be comprehensive, but rather to give students a taste of the usefulness of linear algebra for the conceptualization as well as implementation of solutions to problems in contemporary applications. It is conjectured that familiarity with concrete situations such as these will increase interest and motivation for subsequent courses in linear algebra. (Received September 11, 2009)

1056-G1-587 **Carl C. Cowen*** (ccowen@iupui.edu), IUPUI Dept of Math Sciences, 402 N Blackford St, Indianapolis, IN 46202-3216. *Use of Technology in Teaching the Mathematics of Linear Algebra.* Preliminary report.

Many colleagues assert that in a Linear Algebra classroom, they want to teach *MATHEMATICS* and not technology! In this presentation, the assertion that *MATHEMATICS* can be taught better using technology than without using technology will be defended and illustrated. In particular, examples of mathematical ideas that can be better explored with the use of technology than without will be presented. (Received September 14, 2009)

1056-G1-600 **Josep Ferrer*** (josep.ferrer@upc.edu), Diagonal 647, Departament Matematica Aplicada I, ETS Enginyeria Industrial de Barcelona, 08034 Barcelona, Spain, and **Carmen Ortiz** and **Marta Pena**. *Learning technology to teach mathematics.*

The implementation of Bolonia process in our faculty emphasizes the use of mathematical tools in the technological courses. We present several brief introductions to different technological disciplines in order to make clearer the linear algebra tools and their suitable use, resulting from a seminar developed during last year. (Received September 14, 2009)

1056-G1-822 **Yun Lu*** (lu@kutztown.edu), Mathematics Department, Kutztown University of PA, Kutztown, PA 19530. *Interesting projects while teaching Linear Algebra course.*

I regularly teach Linear Algebra in Kutztown University of PA, and I've been using different methods to engage students. One efficient method is to give students some interesting projects to work on along with the regular course assignment. Those projects mostly focus on the application of Linear Algebra, and they play an important role in motivating students and engaging them throughout the course. During this talk, I will share some of the projects as well as the students' feedback. (Received September 17, 2009)

1056-G1-856 **Matt Boelkins*** (boelkinm@gvsu.edu), Department of Mathematics, A2178 Mackinac Hall, Grand Valley State University, Allendale, MI 49401. *Learning the Language of Linear Algebra: Using Reading Assignments to Immerse Students in Terminology and Ideas.*

Imagine being an average college sophomore encountering linear algebra for the first time. Sometime in the second week of class, after already seeing and hearing a variety of new ideas, terms, and perspectives that seem remarkably different from calculus, you experience a class in which phrases like "linearly independent set", "linearly dependent set", "span of the set $V$", and "linear combination of the columns of $A$" are being used frequently by the instructor. The number of terms alone is overwhelming, and the discussion in class feels less and less helpful. While it should probably occur to you to read the book in advance of class, it is hard to require this habit of yourself, and it is perhaps not apparent how useful this might be.

In this talk, we will describe a structured approach to teaching linear algebra centered on the use of daily reading assignments in advance of class. Specifically, we'll consider the motivation behind this approach, some of the many resulting benefits of these assignments, and practical issues involved from the instructor's point of view. (Received September 18, 2009)

1056-G1-958 **Jeffrey L Stuart*** (jeffrey.stuart@plu.edu), Mathematics Department, Pacific Lutheran University, Tacoma, WA 98447. *Inverses for Matrices that Don't Have Inverses.*

Every student who takes linear algebra learns that the matrix $A$ has an inverse $B$ if and only if $AB = BA = I$, and that if you apply row operations to the augmented matrix $[A \mid I]$ to obtain $[rref(A) \mid M]$ where $rref(A)$ denotes the reduced row echelon form of $A$, then $M$ is the inverse of $A$ exactly when $rref(A) = I$. What happens when $A$ does not have an inverse? This simple question provides a natural opportunity to introduce students to how mathematicians weaken requirements, posit generalizations and seek to preserve desirable properties. Along the way, students learn what $M$ is trying to tell them. (Received September 18, 2009)

1056-G1-970 **Mohammad Khadivi*** (mkhadivi@hotmail.com), M.R.Khadivi, Professor of Mathematics, Dept. of Math., JSU, Jackson, MS 39217. *Inclusion of new applications in a Linear Algebra course, without compromising the coverage of the traditional topics.*

Linear algebra plays a pivotal - in many cases, indispensable-role in understanding and solving many real world problems. One can use the well known fact that any mxn matrix with entries from any given field , not necessarily the field of real number, is equivalent to a row reduced echelon form in order to solve AX=b. Given the aforementioned fact and with the aid of mathematical software we present several cryptosystems as application of linear algebra that could be embedded in topics for this course without compromising the coverage of the traditional topics. (Received September 19, 2009)

1056-G1-1131 **Sang-Gu Lee*** (sglee@skku.edu), Department of Mathematics, Chun-Chun Dong 400, Suwon, Kyoun-Ki 440-746, South Korea, and **Duk-Sun Kim** (mass@skku.edu), Department of Mathematics, Chun-Chun Dong 400, Suwon, Kyoung-Ki 440-746, South Korea. *ICT Linear algebra class model with Sage-math.*

Internet educational environment of Korea has been changed recently. As a result, students expect more use of IT environment in their class. In this talk, we will introduce our linear algebra class with Sage-math based on the ILAS recommendation. (Received September 21, 2009)

1056-G1-1380 **Daniel R. Jordan*** (djordan@colum.edu), Columbia College Chicago, Dept. of Science & Math, 600 S. Michigan Ave., Chicago, IL 60605. *Programming Linear Algebra.*

Offering a course in Linear Algebra to students with a strong foundation in computer programming presents several unique opportunities. Among these is the chance to make use of students' programming skills to deepen their understanding of the mathematical concepts and algorithms. In this presentation, I will describe two programming projects along with the specific mathematical and programming concepts that they reinforce. The first is a "reverse graphing calculator" which determines and graphs the equation of the polynomial passing through a given set of points in the Cartesian plane. The second is a "three-dimensional modeler" which, given three-dimensional coordinates for a set of vertices and specifications for facets, renders an image of the object in perspective and with appropriate shading. These applications require that the students write code for a variety of linear algebra algorithms, including Gauss-Jordan elimination, matrix and vector arithmetic, and others. In addition to strengthening students' mathematical understanding, these projects also help to improve their programming skills as well as to provide them with concrete and relevant examples of the applications of advanced mathematics. (Received September 21, 2009)

1056-G1-1528 **Jennifer Wilson*** (wilsonj@newschool.edu), Eugene Lang College, 65 W. 11th St., New York, NY, and **Karrolyne Fogel**, **Kay Somers** and **Angela Spalsbury**. *Using Linear Algebra to Measure Power.*

There has been a lot of interest recently in mathematics applied to the social sciences and in mathematics and voting. In this talk we look at how linear algebra can be used to compute and analyze power in simple voting games. In simple voting games, players may vote yes or no and the rules of the game specify which combinations of voters are required for motions to pass. Applications include shareholders meetings where shareholders' votes may carry different weights and governing bodies such as the United Nations Security Council where different rules for permanent and temporary members determine when resolutions are passed. There are a number of well-known measures of power including the Shapley-Shubik power index and the Banzhaf measure. We look at how these and other indices of power can be expressed as linear combinations of vectors describing player's contributions to voting coalitions of different sizes. In the case of three voters, we show how the geometry of the simplex and the convex hull of these vectors can be used to show that all measurements of power must result in the same ranking of players' power. These ideas are easily accessible to undergraduates and highlight an interesting use of fundamental concepts in linear algebra. (Received September 22, 2009)

1056-G1-1640 **Melvin A Nyman*** (nyman@alma.edu), Department of Mathematics & Computer Science, Alma College, 614 W. Superior St., Alma, MI 48801, and **John Berry**, **Douglas A Lapp** and **Dennis St. John**. *Eigenvalues and eigenvectors – helping students see what they do.*

We have found that for many undergraduate students in linear algebra eigenvalues and eigenvectors are difficult concepts. Our investigations have indicated very weak connections between eigenvalues and eigenvectors, and other topics in linear algebra. We will discuss some visual approaches that we believe can enhance student understanding of these important ideas and their applications. (Received September 22, 2009)

1056-G1-1707 **David Mazur*** (dmazur@wnec.edu), Department of Mathematics, Western New England College, 1215 Wilbraham Road, Springfield, MA 01119. *One course to serve them all: mathematicians, computer scientists, and engineers.*

Linear algebra courses serve many disciplines but therein lies the challenge. Math majors are familiar with proof and abstraction yet might not have the background to understand the latest application areas. Computer science majors enjoy applications such as image compression, graphics, and search engine design but it takes precious class time to introduce these topics to everyone else. Engineering majors often have no proof-writing experience and have their own set of applications of interest. How can all three groups be effectively served by one course? We highlight some concrete ways that we have overcome these challenges in teaching undergraduate linear algebra. (Received September 22, 2009)

1056-G1-1868 **Gulden Karakok*** (gulden.karakok@math.umu.se), Matematik och Matematisk Statistik, Umea Universitet, 901 87 Umea, Sweden, and **Corinne A. Manogue**. *Student-centered linear algebra activities.*

The purpose of this talk is to describe two student-centered linear algebra activities that are implemented during a linear algebra review week for junior level physics students. These particular activities were designed to refresh students' understanding of linear algebra topics (such as linear transformation, determinant, eigenvalues and eigenvectors) used frequently in a series of quantum physics courses. One of the goals of the activities was to help students to make connections between geometric and algebraic interpretations of concepts of eigenvalues and eigenvectors. Students' comments about the activities will also be shared in the presentation. (Received September 22, 2009)

1056-G1-1931 **David E. Meel*** (meel@bgsu.edu), P.O. Box 313, Bradner, OH 43406-0313. *Looking at Conceptual Online Linear Algebra applets.*

In this talk, a suite of conceptual online linear algebra applets will be presented. The applets, designed using JavaSketchpad, are accompanied with student activities and theoretical discussions of the nature of the applet and the goal of each applet. Several of the applets have been published in JOMA although these have been enhanced to address some of the shortcomings previously identified. In particular, the applets focus on concepts/techniques such as Gaussian Elimination, Matrix Transformations (2D to 2D and 3D to 3D), Matrix Multiplication/Factorization, Eigenvalues and Eigenvectors, Diagonalization, Singular Value Decomposition and Matrix Iteration. This talk will culminate with opportunities for the audience to suggest other possible applets that would help students explore linear algebra concepts. (Received September 22, 2009)

1056-G1-2000 **Peg Howland*** (peg.howland@usu.edu), Department of Mathematics & Statistics, 3900 Old Main Hill, Logan, UT 84322-3900, and **Brynja R. Kohler** (brynja.kohler@usu.edu), Department of Mathematics & Statistics, 3900 Old Main Hill, Logan, UT 84322-3900. *Three tested ways to empower students to engage in linear algebra.*

"This is nothing like calculus." How do we turn that first-week refrain into abstract mathematical thinking by the end of a semester? Our response involves three class-tested pedagogical tools for motivating students to open their minds to linear algebra. The goal of the first was to avoid presenting a laundry list of dry rules for matrix algebra. Instead, we broke the class into collaborative groups to work on proofs. By throwing the commutative rule for matrix multiplication into the mix, we generated critical thinking that merged all groups into one by the end of class. A difficult exam precipitated the second tool: a linear algebra stimulus package. This took the form of a MATLAB exercise exploring the rank of matrix outer products, a topic usually reserved for higher level courses. As we moved into the final third of the course, we encouraged students to buy into the increasingly abstract material by helping to shape the final exam. To cap the course, they were prompted to write the ultimate questions of orthogonality, eigenvalues, and everything. We will share the descriptions and results of these experiments in our report. (Received September 22, 2009)

1056-G1-2002 **Elyn Rykken*** (elrykken@muhlenberg.edu), Muhlenberg College, Allentown, PA , and **Maureen Carroll**, University of Scranton, Scranton, PA. *Transitioning to a Laguerre Basis.*

Change of basis problems, in particular those between polynomial spaces, are a staple of every linear algebra textbook. Often one is asked to change from the the standard basis $\{1, x, x^2, x^3, ..., x^n\}$ to some other basis, perhaps $\{1, 1-t, 2-4t+t^2, 6-18t+9t^2-t^3\}$ when the space is $\mathbb{P}_3$. The new basis given here consists of Laguerre polynomials, an example of the broader category of orthogonal polynomials. As our students often wonder why we are interested in such problems, our quest to provide context led us to discover the rich history of these polynomials. They arise in many areas of mathematics and produce a wealth of diverse applications. For our talk we will present some background material and a peculiar fact about Laguerre polynomials. (Received September 22, 2009)

1056-G1-2056 **K. 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** (kattele@csu.edu), IL. *Linear Algebra Done Right! Back to Grassmann.*

Linear algebra as enunciated by its founder Grassman, and Clifford is a powerful unifier of geometries and algebra. However, they way linear algebra is now taught do not fully make use of their ideas. Consequently, students are not provided with all the tools that they could have had to apply linear algebra more broadly and efficiently. They are stymied in their progress by having some key definitions such as linear independence appear to be artificial and unmotivating, and by not fully understanding fundamental concepts such as duality.

The challenge is to enhance the current course material by incorporating ideas of Grassmann and Clifford to bring about better understanding and wider applicability, but still stay within the normal parameters of a sophomore or junior course. Convincing others of its feasibility is a central goal of this presentation. It will be demonstrated the wedge product of vectors can be easily interpreted geometrically and all the basic properties of vector spaces such as the Steiniz Base Exchange theorem can be derived by using wedge products.

The computational foundation and algebraic manipulations that students gain will also prepare them to more easily acquire the culture of abstract algebra. (Received September 23, 2009)

# The MAA SUMMA Program Turns 20—A Retrospective

1056-G5-87 **Florence Fasanelli*** (ffasanel@aaas.org), AAAS, 1200 New York Ave. NW, Washington, DC, DC 20005. *Stengthening Underrepresented Minority Mathematics Achievement Intervention Programs.*

The magnitude of the underrepresentation of African Americans, Hispanic Americans and Native Americans in mathematics-dependent fields was well known in 1991 when the MAA's SUMMA Intervention Programs began making small grants to mathematics professors to learn how to conduct pre-college projects on their campuses. The long term goal was to have a project on every campus to encourage access of students, particularly minority students, to the further study of mathematics. The extent to which the goal was reached will be reported. Examples of successful ongoing programs will encourage mathematicians today to continue this work which was supported through the MAA until 1998. Experiences of mathematicians who were pre-college students in SUMMA Consortium projects assist in understanding the impact of the Intervention Programs. (Received July 24, 2009)

1056-G5-282 **Lida K. Barrett*** (lidak@bellsouth.net), TN. *Minorities and the MAA, Initial Steps.*

Len Gillman, while President of the MAA, appointed a Task Force on Mathematics and Minority Participation chaired by Louise Raphael. Of the 42 recommendations of the Task Force on Mathematics and Minority Participation (1989) the most important was the establishment of an MAA Office to increase minority participation in mathematics. The Strengthening Underrepresented Minority Mathematics Achievement (SUMMA) Program of the Mathematical Association of America was established in 1990 with the charge to increase the representation of minorities in the fields of mathematics, science and engineering and improve the mathematics education of minorities. Bill Hawkins was its first director. At the same time the Committee on Committees of the MAA, aware of all the recommendations of the Raphael Committee in 1989, appointed 39 minorities to the various committees of the MAA. There had been minority membership on committees in the past but this was an effort to increase the participation of minorities in the network of leadership of the organization. Over the years these two efforts have contributed in highly significant ways to the MAA. (Received August 25, 2009)

1056-G5-438 **Manuel P. Berriozábal*** (manuel.berriozabal@utsa.edu), Department of Mathematics, University of Texas at San Antonio, San Antonio, Texas, TX 78207. *The San Antonio Prefreshman Engineering Program Turns 30 - A Retrospective.*

In 1979, the San Antonio Prefreshman Engineering Program (or SAPREP) began its first summer of operation at the University of Texas at San Antonio in response to the challenge of low academic expectations from the minority community, primarily Mexican-American, in San Antonio. SAPREP is a seven week, summer, mathematics-based academic enrichment program designed to identify achieving middle school and high school students and preparing them for college studies and careers in science, technology, engineering, and mathematics. The program focuses on the development of abstract reasoning skills and problem-solving skills, and emphasizes the learning of academic content over the learning of processes. Over a three summer sequence, the participants learn topics in mathematics usually reserved for beginning upper division mathematics majors beginning with basic mathematical logic and some immediate applications, algebraic structures, and statistics. The students also engage in small group activities in engineering and physics. Over 13,000 middle school and high school students have completed at least one summer of SAPREP. Beginning in 1986, SAPREP has been replicated throughout Texas in other community and senior colleges, and since 1997 in other states. (Received September 07, 2009)

1056-G5-1054 **Sylvia T. Bozeman*** (sbozeman@spelman.edu), Box 270, Spelman College, Atlanta, GA 30314. *Some Challenges to Broadening Participation in Mathematics at the Undergraduate Level.*

There are several identifiable challenges likely to face institutions in attracting students from underrepresented cultural and racial groups into undergraduate mathematics. In addition to identifying the challenges, this presentation will outline a set of key elements commonly used to address these specific challenges. Examples will be given to show how one institution has woven these key elements together to create effective programs and increase their bachelor's degree completion rates. Some discussion of the college-to-graduate school transition for the students from underrepresented groups will also be included. (Received September 20, 2009)

1056-G5-1176 **Robert E. Megginson*** (meggin@umich.edu), University of Michigan, LSA Dean's Office, 2216 LSA Building, 500 S. State St., Ann Arbor, MI 48109-1382. *Speed Bumps and Potholes in the Road to Strengthening Underrepresented Minority Mathematics Achievement, Past, Present, and Future.*

SUMMA has been a driving force toward doing exactly what its name promises: strengthening underrepresented minority mathematics achievement. However, the road toward that goal has not been completely smooth, with some speed bumps and potholes along the way as well as looming ahead. The purpose of this talk is to put some of these on the table, along with their reasons (generally external to the program), and, possibly, generate a discussion about how we can learn from these and perhaps use that knowledge to smooth the road ahead. (Received September 21, 2009)

1056-G5-1324 **William A. Hawkins*** (bhawkins@maa.org), Department of Mathematics, University of the District of Columbia, 4200 Connecticut Avenue, N.W., Washington, DC 20008. *The Director of SUMMA looks at SUMMA past, present, and future.*

Since its inception at MAA Headquarters in 1990, SUMMA has conducted many initiatives to increase opportunities for minority students and faculty. Yet, at the same time, SUMMA has focused on capacity-building within the mathematics community at-large. The author directs SUMMA and will look at lessons of the past 20 years and challenges for the present and future. (Received September 21, 2009)

1056-G5-1647 **Sandra L. Richardson*** (sandra.richardson@lamar.edu), Lamar University, Department of Mathematics, Beaumont, TX 77710, and **David S. Torain** (david.torain@hamptonu.edu). *Exploration of a Mathematics Enrichment Summer Camp for Underrepresented High School Students.*

This session will introduce a successful framework for the development and advancement of the Tensor SUMMA-funded Lamar Achievement in Mathematics Program (LAMP) at Lamar University. LAMP, a 2009 first year initiative at Lamar University, is a free summer mathematics camp for underrepresented and/or economically disadvantaged mathematically talented Southeast Texas high school students interested in exploring mathematics as a college major or career option. The mission of the initiative is to expose mathematically gifted students to the beauty and variety of mathematics that extends beyond the typical high school curriculum and encourage them to consider postsecondary study and careers in mathematics.

Details of the three week summer LAMP experience include LAMP Scholars' engagement in numerous instructional and exciting activities, focusing on the exploration of interdisciplinary areas of mathematics in 6 different mathematics courses (Game Theory, Discrete Mathematics, Problem Solving, Magic of Mathematics, Geometry, and Number Sense). Scholars also participate in weekly field trips, work collaboratively to compile a video for the annual Math Awareness competition, and interact with professionals from various science, technology, engineering, and mathematics disciplines. (Received September 22, 2009)

1056-G5-1653 **Wade Ellis*** (wellis@ti.com), 4562 Alex Drive, San Jose, CA 95130, and **Tatiana Shubin** (shubin@math.sjsu.edu), Mathematics Department, San Jose State University, One Washington Square, San Jose, CA 95192. *AIM Math Teachers' Circle Immersion Workshop.*

There were 19 middle school teachers who participated in Math Teachers' Circle Immersion Workshop July 6-10, 2009. The workshop was organized by Brian Conrey (AIM), Tom Davis, Harold Reiter (UNC), Tatiana Shubin (SJSU), and Joshua Zucker. This was the third summer the workshop has been offered and the first time SUMMA funds were available for 7 teachers from middle schools serving minority and socio-economically disadvantaged populations. The presentation will begin with a brief discussion of the purpose of the workshop and the workshop schedule, followed by examples of the topics covered and student work.

The topics are chosen to create learning situations that are within the reach of middle school mathematics teachers, but difficult enough to encourage participants to collaborate and to discover the frustration and deep satisfaction that comes from working on and solving difficult problems. Teaching methods that encourage students to reflect on their work will be discussed as part of the review of each learning situation. Teachers will pass on their delight in mathematics having had these experiences themselves. (Received September 22, 2009)

1056-G5-1938 **James A. Mendoza Epperson*** (epperson@uta.edu), Box 19408, Department of Mathematics, The University of Texas at Arlington, Arlington, TX 76019-0408. *Successful Intervention Programs in Mathematics for Undergraduates Historically Underrepresented in the Mathematics-based Disciplines.*

In this talk, we highlight successful intervention programs for increasing achievement in mathematics in higher education for students historically underrepresented in the mathematics-based disciplines. We examine the Emerging Scholars Program (ESP) as an effort which has consistently supported high achievement in introductory mathematics courses for over thirty years (Hsu, Murphy, & Treisman, 2009). We also discuss broad features of successful programs including the opportunities and challenges faced in creating and maintaining these programs. (Received September 22, 2009)

1056-G5-2139 **Dennis Davenport*** (ddavenpo@nsf.gov), National Science Foundation, Division of Undergraduate Education, 4201 Wilson Blvd., Arlington, VA 22230, and **Bonita Porter** (porterbm@muohio.edu), Miami University, Department of Mathematics, Oxford, OH 45056. *Starting and Running an REU for Minorities and Women.*

The decreasing number of US citizens with advanced degrees in the mathematical sciences is a growing concern. Also of concern is the small number of advanced degrees in the sciences going to African Americans, Latinos, and women. Several Research Experience for Undergraduates (REU) programs have been developed to address these issues. In this talk we describe the design of our ongoing program, the Summer Undergraduate Mathematical Sciences Research Institute (SUMSRI) in the Department of Mathematics and Statistics at Miami University. (Received September 23, 2009)

# *Mathematical Texts: Famous, Infamous, and Influential*

1056-H1-234 **Lawrence A. D'Antonio*** (ldant@ramapo.edu), Ramapo College of New Jersey, Mahwah, NJ 07430. *Osgood's Theory of Functions.*

William Fogg Osgood (1864-1943) was one of the first American mathematicians who earned a substantial reputation within European mathematical circles. In 1907 he published his Lehrbuch der Funktionentheorie (later editions and subsequent volumes were published up to 1932). As Edward van Vleck noted, "Osgood's Theory of Functions is a monument of American scholarship." This work is one of the classic texts on complex analysis. Osgood begins with a thorough discussion of functions of a real variable, ending with the Heine-Borel theorem. He then moves onto functions of a complex variable (volume 2 includes material on functions of several complex variables). Osgood's treatment was widely noted for its depth and breadth. For example, Osgood proves the existence of Green's function for simply connected regions. In this talk we discuss the scope of Osgood's book, and its reception in both Europe and the United States (it was widely adopted even though it was in German). We also compare the work to other complex analysis texts of the period, e.g., Harkness and Morley, Burkhardt, Bieberbach, Landau, and Knopp. (Received August 18, 2009)

1056-H1-495 **James J. Tattersall*** (tat@providence.edu), Department of Mathematics, Providence College, Providence, RI 02918. *Bougainville's Tratie du Calcul-Integral.* Preliminary report.

Louis Antione Bougainville (1729-1811) attended the University of Paris where he studied mathematics, classics, and, law. He qualified as an advocate, but chose instead to pursue a military career. While in Paris, he came under the influence of Jean Le Rond d'Alembert. In 1752, Bougainville finished the first volume of the *Tratié du calcul-intégral*. The book was intended to be a supplement to L'Hôspital's *Analyse des infiniment petits*. Bougainville's genus, like Euclid, was that of being an excellent synthesizer. The text begins with a discussion of functions their derivatives and antiderivatives. Subsequently, the book resembles a handbook on integration techniques. The first volume ends with the evaluation of elliptic integrals. The second volume of *Traité* was published in 1756. It was the first book devoted exclusively to differential equations. A third volume devoted to applications never materialized. We focus on the contents of the book and some of Bougainville's other adventures. (Received September 10, 2009)

1056-H1-553 **George M. Rosenstein*** (george.rosenstein@fandm.edu), 644 State St., Lancaster, PA 17603. *"The Method of Rates:" The Books of Rice and Johnson.*

In his 1890 survey of mathematics teaching in the United States, Florian Cajori asked, "What method of teaching calculus do you favor, that of limits, the infinitesimal, or some other?" Among the 154 responses to this question, 16 or 11% said they favored the method of rates. Among the scattering of text books available to these teachers were those of J. Minot Rice and W. W. Johnson.

These books appeared between 1873 and 1909. This period covers the peak of interest in this method, which attempts to revive and revise Newton's fluxions in a more "modern" form.

In this paper, I will look at the authors, their motivation, and some of the details of their presentation (Received September 12, 2009)

1056-H1-580 **Colin Bryan Powell McKinney*** (cbmckinn@math.uiowa.edu), University of Iowa, Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52242-1419. *Conjugate Diameters: Apollonius of Perga and Eutocius of Ascalon.* Preliminary report.

This talk will address the relationship between two works: Apollonius' *Conics* and Eutocius' commentary thereon. Eutocius' commentary should be seen as more than just a secondary text, since it is likely no coincidence that he comments on Books I-IV and that these books are the precise ones which are extant in Greek. In fact, his commentary is tied to the *Conics* and its textual transmission, since Eutocius also arranged and edited a new edition of Apollonius' work. I will illustrate how the two texts and their authors should be seen as linked, or "conjugate", along with ways in which they are not. (Received September 13, 2009)

1056-H1-818 **Herbert E Kasube*** (hkasube@bradley.edu), Department of Mathematics, Bradley University, Peoria, IL. *Newton's Principia : What is in it and why should we care?*

Published in 1687, Isaac Newton's Principia Mathematica stands out as a monument to his brilliance. This talk will discuss some of the highlights in this work and well as the influence it has had over the centuries. (Received September 17, 2009)

1056-H1-836 **Alejandro R. Garciadiego*** (gardan@servidor.unam.mx), Caravaggio 24, Col. Nonoalco Mixcoac, Del. Benito Juárez, 03700 Mexico, D. F., Mexico. *The Elements, its evil influence.* Preliminary report.

Euclid's Elements is the most influential book in the history of the teaching of mathematics. Even today, and perhaps inadvertently, most textbooks follow its synthetic approach of presenting some basic principles and, from them, logically deduce the rest of the subject matter. Furthermore, this work has enormously impacted the foundations and instruction of other disciplines (e.g., chemistry and ethics, among others). In fact, it has been repeatedly affirmed that, in the Western hemisphere, no other mathematical book has ran through more different editions or reprints. But very few critics have ever exposed some of its negative consequences. The goal of this talk is to discuss some factors of its detrimental influence, especially concerning the history of the teaching of mathematics. (Received September 17, 2009)

1056-H1-1018 **Clemency J Montelle*** (c.montelle@math.canterbury.ac.nz), Department of Mathematics and Statistics, University of Canterbury, Private Bag 4800, Christchurch, 8140, New Zealand. *Parallel Insight, Priority, and Pre-eminence: John Napier, Joost Bürgi, and Famous Works on Logarithms.*

'Logarithms' mused French mathematician Laplace almost two centuries after their inception, 'by shortening the labors, doubled the life of an astronomer'. Indeed, there has never been any doubt as to the importance of logarithms; a mathematical insight whose usefulness has persisted in different aspects to the present day. Within years of their introduction, they became indispensable for mathematicians, astronomers, navigators, and geographers alike. The question of their origins, however, is more contentious. At least two scholars, the Scottish mathematician John Napier and Swiss craftsman, Joost Bürgi produced proposals which embodied the logarithmic relation and within years of one another produced tables for its use. Both were motivated by removing the computational complexities of the various arithmetical operations involving large numbers that practitioners were facing; Napier saw this as 'troublesome to mathematical practice' and Bürgi sought to 'lift the difficulties'. But their proposals were in many ways fundamentally different. In light of this parallel discovery, I will compare the approaches and achievements of both scholars with an emphasis on Napier, and explore the issue of priority and pre-eminence in the history of mathematics. (Received September 20, 2009)

1056-H1-1095 **Andrew B. Perry*** (perryand@yahoo.com). *Warren Colburn's "First Lessons in Arithmetic".*

Warren Colburn's "First Lessons in Arithmetic" (1821) and his other arithmetic and algebra books revolutionized the American mathematics curriculum. Colburn taught concepts rather than recipes and procedures, and pioneered the inductive method of instruction. He not only sold 3,500,000 books, but had a profound influence on the educators of his era, and indirectly, on mathematics education far into the future. (Received September 20, 2009)

1056-H1-1140 **Clemency J Montelle*** (c.montelle@math.canterbury.ac.nz), Department of Mathematics and Statistics, University of Canterbury, Private Bag 4800, Christchurch, 8140, New Zealand. *Rip-off or Reverence? Hypsicles of Alexandria and the fourteenth book of the Euclid's Elements.*

One cannot be entirely sure what was on the mind of Alexandrian Mathematician Hypsicles (fl. ca. 150 BCE (?)) when he named a work he wrote 'Book Fourteen of Euclid's Elements'. This book contains a detailed study on the comparison between a dodecahedron and an icosahedron inscribed in the same sphere in eight propositions and various lemmas. Did Hypsicles really hope that his readers would consider it a natural and essential continuation of the Elements, or was it intended simply to be an inspired complement of the work which was, even by his time, famous? Indeed, Hypsicles's presentation is unmistakably Euclidean in style but with some vital differences. This talk will cover some highlights of the detailed textual, technical, and contextual study of the mathematical content of his work I am carrying out, and from this, detect Hypsicles's motivations to title his work as such and what it reveals about the broader mathematical climate of his time. (Received September 21, 2009)

1056-H1-1323 **V. Frederick Rickey*** (fred-rickey@usma.edu), Department of Mathematical Sciences, United States Military Academy, West Point, West Point, NY 10996. *Eric Temple Bell's* Men of Mathematics*: From Influential to Infamous.*

Eric Temple Bell (1883–1960) was a gifted mathematician who received the Bôcher Prize in analysis in 1924, served as President of the MAA, 1931-33, and wrote some 250 research papers, 13 books, 13 novels, and a book of poetry. But he is best known for his *Men of Mathematics* (1937), a book which has never gone out of print. We will judge this book by the standards of his times: did he use his historical sources wisely and were there sources he should have used? Today this book is still known to build students' interest in learning mathematics but also for its prejudices, exaggerations, and fanciful tales. But how was it received when it appeared? There is no doubt that this book has been tremendously influential, prodding many to careers in mathematics. But is it still worthwhile to put in the hands of young students? We will discuss some of the controversies that surround Bell and his book. (Received September 21, 2009)

1056-H1-1401 **Kathleen M Clark*** (drkclark@gmail.com), School of Teacher Education, 1114 West Call Street, Tallahassee, FL 32306-4459. *For the good-hearted reader: Joost Bürgi, the history of logarithms, and a work that should have been famous.*

When discussing the emergence of the logarithm concept, most historians of mathematics feature and detail the achievements of Scottish mathematician John Napier (1550-1617), and give at most partial mention to his Swiss contemporary Joost Bürgi (1552-1632), despite the latter's independent and original, near simultaneous account. Bürgi was a craftsman employed in the court of Duke Wilhelm II, and wished to address the difficulties of the lengthy arithmetical operations when computing with large numbers. More importantly, he sought to create "general tables" that would improve upon the need for a multiplicity of tables for all manner of calculation. To better understand Bürgi's contribution, I translated, analyzed, and interpreted his primary source text *Arithmetische und Geometrische Progress Tabulen*, which was finally published in 1620. I present here the salient features of Bürgi's contribution and some of the features of his tables of logarithms. As well as providing a richer account than ever before, I set the scene for more reflective questions about the issues of parallel discoveries in mathematics and what they can reveal about the mathematics at the time in which such multiple insights arise. (Received September 21, 2009)

1056-H1-1420 **Toke L Knudsen*** (toke.knudsen@oneonta.edu), Department of Mathematics, SUNY Oneonta, 108 Ravine Parkway, Oneonta, NY 13820. Geometry and Algebra in Ancient Civilizations *by B. L. van der Waerden: A Text Exploring the Origin and Development of Ancient Mathematics.*

Bartel Leendert van der Waerden (1903–1996) was a Dutch mathematician, famous for his work in the field of algebra, but also respected for his contributions to the history of mathematics. His *Ontwakende wetenschap* (1950), translated into English as *Science Awakening* (1954), has provided much inspiration to students of the history of mathematics. In *Geometry and Algebra in Ancient Civilizations* (1983), however, van der Waerden entered a more speculative path in his investigation of ancient mathematics, following ideas articulated by scholars such as Abraham Seidenberg. A basic theme of the book is the idea that there is a pre-Mesopotamian ancestor to the mathematics in the ancient cultures of Mesopotamia, Egypt, India, Greece, and China. Van der Waerden argued that in mathematics, diffusion is much more likely than independent discovery, and that therefore the mathematics of these cultures is derivative from the mathematics of the older, pre-Mesopotamian, culture. This and other assumptions made by van der Waerden are problematic, and will be critiqued both in the light of the knowledge available at the time of the publication of the book, as well as in the light of more recent research. (Received September 21, 2009)

1056-H1-1842 **Thomas Drucker*** (druckert@uww.edu), Department of Math. and Computer Sciences, University of Wisconsin–Whitewater, Whitewater, WI 53190. *The Historian and the Mathematician: The Reception of the Biography by Michael Sean Mahoney of Pierre de Fermat.*

In 1973 Michael Sean Mahoney of Princeton University's Program in History and Philosophy of Science published a volume on the mathematical career of Pierre de Fermat with Princeton University Press. It was received by a celebrated and caustic review by Andre Weil, down the street at the Institute for Advanced Study. Many of the criticisms raised by Weil seem to reflect a mathematician's approach to how history ought to be done. It is worth examining other contemporary reviews, as well as how the biography has stood the test of time. (A new edition was published after the announcement of the proof of Fermat's Last Theorem by Wiles.) While both the protagonists have died, the issues remain alive and reflect some of the distinctive aspects of the history of mathematics among the histories of other sciences. (Received September 22, 2009)

# Mathematics and Sports

1056-H5-81 **Santanu Chakraborty*** (schakraborty@utpa.edu), Department of Mathematics, University of Texas - Pan American, 1201 West University Drive, Edinburg, TX. *Introducing some new and already existing statistical studies related to a sports mostly popular in the eastern hemispheres.*

Cricket is the sports that is mostly popular in the eastern hemisphere of the world. But because of newer versions like Twenty-twenty cricket, it is now getting popular in the western hemispehere too. However, much before the arrival of limited overs cricket, the cricket statisticians came in to existence to study the numbers involved in this game in their own way with limited tehnological freedom. So, even before the modern computer era, there had been huge databases on cricket maintained by the statisticians. It is, therefore, no wonder that these databases are now relatively easier to maintain after better and better computers with huge memory becoming available. But the best things is - some really interesting statistical studies are now possible which was not seen earlier - like which players succeed more in the beginning of a series than at the end of a series, which is the most comfortable batting position for a batsman, which bowlers pick up more wickets in the middle overs of a limited overs match etc. The purpose of this talk is to describe some existing and new results of such studies and welcome more and more scholars to this exciting area. The speaker will take the help of the best cricket website, namely, www.cricinfo.com for his studies. (Received July 22, 2009)

1056-H5-236 **Paul Raymond Bouthellier*** (pbouthe@pitt.edu), 504 East Main Street, University of Pittsburgh-Titusville, Titusville, PA 16354. *Creating a Sports Video Game using Mathematical Modeling.*

Many of the most popular video games are based on sports. These programs are created by modeling the mathematics and physics of the sport. In this talk, the computer packages Flash, Swift3D, Poser, and Carrara, as well as Actionscript classes from PaperVision3D will be used to create a simple interactive golf simulation.

A three-dimensional golf ball, club, tee, ground, flag/pin, and golfer will be modeled. These 3-D models will be projected onto the 2-D screen. To view the flight of the ball from multiple angles, a user controllable rotatable camera will be created using quaternions.

The flight of the ball will be modeled using: the speed and angle the ball leaves the tee, air resistance, the lift of the rotating ball, and effects of wind. (Received August 18, 2009)

1056-H5-314 **Roland Minton*** (minton@roanoke.edu), 620 Beech Road, Salem, VA 24153.
*Tigermetrics: Statistical Analysis of the PGA Tour.* Preliminary report.

Golf statistics have been revolutionized by Shot Link data that records ball locations to the inch. These statistics are used to create a rating system for PGA golfers. This rating system rates the golfers in each of several component skills. Each of the years 2003-2008 has been analyzed. The ratings show why Tiger Woods is number one, by how much he is number one, and possibly reveal a flaw in his game. (Received August 28, 2009)

1056-H5-374 **Douglas Ensley** and **Joseph A. Gallian*** (jgallian@d.umn.edu), 1117 University Drive, University of Minnesota Duluth, Duluth, MN 55812, and **Howard Penn**. *Mathematics Awareness Month 2010: Mathematics and Sports.*

In this talk we will show the official posters and web material on the theme of Mathematics and Sports we created for Mathematics Awareness month April, 2010. (Received September 02, 2009)

1056-H5-380 **Howard L. Penn*** (hlp@usna.edu), Mathematics Department, 572 Holloway Rd, U.S. Naval Academy, Annapolis, MD 21012. *Did Humidifying the Baseball Decrease the Number of Homers at Coor's Field?*

Coor's Field, where the Colorado Rockies play, has always been know as a home run friendly ballpark. In 2002, the Rockies began humidifying the baseballs that are used in their home games. In this paper, we will use elementary statistics to examine the title question. (Received September 03, 2009)

1056-H5-512 **Jacqueline Brannon Giles*** (jbgiles@yahoo.com), 13103 Balarama Drive, Houston, TX 77099. *Exploring NFL Data to Determine "Who is the Greatest of Them All?".* Preliminary report.

Exploring the various ways of analyzing, describing and forecasting outcomes in sports should be used in the 21st century.

A project has been designed to inspire deeper discussions in sports and academic communities. The project is at the introductory level, and effective decision-making and intellectual development are expected in the participants.

The purpose of this presentation and the related handout is to foster discussion and a forum on how we might explore studies of the Oakland Raiders' performance, in the past, present and future.

Linear regression and/or least squares can be used. Small groups in the classroom setting can also do research and apply floating trend analysis or mathematical modeling in the project, if applicable.

The project can have two phases:

1. Only using charts, and graphs, etc. (Fundamental) 2. If the analysis includes regression or trend analysis, then the total points will be greater. (Advanced)

Two projects will be selected for publication on the Bleacher Report. Bleacher Report has designed a Sports and STEM team page where articles can be uploaded and shared in the public domain. (Received September 11, 2009)

1056-H5-762 **Jeff Hamrick*** (hamrickj@rhodes.edu), 2000 N. Parkway, Memphis, TN 38112, and **John M Rasp** (jrasp@stetson.edu), 421 N. Woodland Blvd., Unit 8398, DeLand, FL 32720. *A Nonlinear Approach to Modeling Success in Baseball.*

Baseball is a game of truisms. "Championships are won on pitching and defense." "Hitting performance is more consistent than pitching performance." Claims such as these are often based upon intuition, and are sometimes abetted by statistical analysis. The traditional Pearson correlation is an important and useful tool in this situation. However, the assumptions associated with the Pearson correlation (linearity and homoscedasticity, for example) may not be valid for baseball data. By relaxing these requirements, we obtain a relatively new statistical tool, a "local correlation," that measures the strength of the relationship at a given location in the distribution of the covariate. We then apply this technique in the context of several baseball situations, examining (for example) whether pitching and defense do correlate particularly well with success for the very best teams. (Received September 21, 2009)

1056-H5-928 **Reza D Noubary*** (rnoubary@bloomu.edu), Department of Mathematics, Bloomsburg University, Bloomsburg, PA 17815. *Analysis of a Table Tennis Game: A Teaching Tool.*

A game of table tennis is analyzed using elementary concepts of calculus, probability, and linear algebra. The analysis demonstrates different modeling approaches and makes a comparison between the results under the new and the old rules of the game. It also illustrates steps involved in mathematical modeling and points out the possible expansion of it. Some hints regarding the use of materials for teaching is also included. (Received September 18, 2009)

1056-H5-996 **Maryam Vulis*** (mlv2007@earthlink.net), 67-67 Burns St, Forest Hills, NY 11375. *How Game Players Get Ranked - The Mathematics of Elo Ratings.* Preliminary report.

This presentation will discuss the Elo rating system originally developed for chess and presently used for other games. The discussion will include the surprisingly non-trivial mathematical aspects of the Elo system and its vulnerabilities which were later rectified. (Received September 19, 2009)

1056-H5-1975 **Anthony Tongen*** (tongenal@jmu.edu), MSC 1911; Department of Mathematics, James Madison University, Harrisonburg, VA 22807. *Biomechanics of Running and Walking.*

Running and walking are integral to most sports and there is an incredible amount of mathematics involved in examining the forces produced by just one foot contacting the ground. This paper will discuss biomechanical terms related to running and walking such as ground reaction force, duty factor, and impulse. We will then mathematically model the vertical ground reaction force curves for both running and walking, successfully reproducing experimental data. Finally, we will discuss the biological implications of the mathematical models and present two great applications of integration. (Received September 22, 2009)

# *Mathematics, Equity, Diversity, and Social Justice*

1056-H7-300 **J B Fink*** (fink@kzoo.edu), Department of Mathematics, Kalamazoo College, Kalamazoo, MI 49006, and **E D Nordmoe** (enordmoe@kzoo.edu), Department of Mathematics, Kalamazoo College, Kalamazoo, MI 49006. *Keeping the Doors Open: A Summer Algebra Camp for Under-represented Minority Middle School Students.*

Of all pre-college curricula, the highest level of mathematics one studies in secondary school has the strongest continuing influence on bachelor's degree completion. Minority and low-income middle school students who could succeed in the college prep math and science courses often let the door close on mathematics without realizing what else the door is closing on. For the last five years Kalamazoo College has offered a two-stage program for these student that addresses this situation: a two week intensive mathematics camp on the Kalamazoo College campus in the summer, followed by a twice-weekly mathematics tutoring program on the campus during the following school year. This is not a remedial program. It is intended for students who have the potential to succeed in college prep math and science courses but who need some encouragement to continue learning the mathematical prerequisites. This talks describes the details of this program, including recruitment, logistics, curriculum, and assessment; discusses some of the difficulties we have faced and how we overcame them; and gives quantitative and qualitative measures of assessment that suggest both some successes of the program over its first five years and where we believe improvements can be made. (Received August 26, 2009)

1056-H7-406 **Marcus Hung*** (marcus@algebra-trm.org), 45 Conkling Street, San Francisco, CA 94124. *The Algebra Project: Building Math Literacy.*

This workshop will be led by current Algebra Project teachers and students from Thurgood Marshall Academic High School in San Francisco. The workshop will provide participants with an overview of the Algebra Project, including the rich history that stems from Bob Moses' work during the Civil Rights movement as well as the current goals of the new high school materials development. Participants will learn about the Algebra Project experience from listening to current students, watching video presentations, and doing some of the math themselves! There will be demonstrations of the experience-based curriculum which highlight the key pedagogical approach of the Algebra Project. Come learn about this alternative curriculum that focuses on diminishing the predictive power of demographics in mathematics education! (Received September 04, 2009)

1056-H7-486 **Jack Bookman*** (bookman@math.duke.edu), Mathematics Department, Box 90320, Duke University, Durham, NC 27708. *Mathematics as a Subversive Activity – Questioning Authority and Promoting Independent Thinking.*

Mathematics educators are often shy about talking about the issues of equity, diversity, and social justice in their classes for fear that they might be accused of indoctrinating their students or of being too "political." Yet, learning to think independently and to base conclusions on evidence and reason are both vital to the nature of mathematical reasoning AND to promoting social justice. We have all taught students who refuse to think for themselves, won't solve problems that don't match the template and can't decide if their answers are right or reasonable without an answer key. In this presentation, I will discuss how, by addressing these attitudes in mathematics class, we can get students to question authority and think independently. I will discuss how, every day in our classrooms, we can promote these qualities as virtues of mathematics and citizenship. (Received September 09, 2009)

1056-H7-885 **Andrew Miller*** (andrew.miller@belmont.edu), Dept. of Mathematics and Computer Science, Belmont University, 1900 Belmont Blvd, Nashville, TN 37211. *Service Learning in Support of Financial Literacy.*

In Fall 2008, I taught an interdisciplinary course that investigated mathematical, political, and social issues that arise in the context of consumer credit. The course included a service-learning component in which my students worked with a local mortgage crisis counseling service and the local Habitat for Humanity chapter. I will share the details of the student projects, discuss the reflections I paired with the projects, and highlight a few points to consider for faculty who are considering adding service-learning to their courses. (Received September 18, 2009)

1056-H7-940 **Bryan Nankervis*** (bn10@txstate.edu), 2522 Deer Stand Loop, San Marcos, TX 78666. *Gender Inequity in the National Merit Scholarship Program.*

This paper investigates gender inequity in the National Merit Scholarship selection process. Through a statistical analysis utilizing data provided by the College Board, it is predicted that most National Merit semifinalists and finalists are male despite the fact that the majority of participants in the competition are female. This is due to males' higher average scores and greater variability on the mathematics portion of the PSAT, which shares differential validity concerns with the quantitative section of the SAT in terms of gender. These instruments are solely designed to predict first-year college success, but as this study demonstrates, the gender gaps in mathematical performance have little to do with college readiness, but rather are a consequence of the misaligned content of the exams as well as the environment in which they are administered. This study underscores the problematic practice of using PSAT cutoff scores as the sole measure of merit in the first two phases and SAT scores in the final stage of the National Merit Scholarship competition. The selection process is plainly at odds with best practices in the use of standardized tests and has serious implications in terms of recruitment and retention of women in the mathematical sciences. (Received September 18, 2009)

1056-H7-991 **Judith M. Kysh*** (JudyKysh@gmail.com), 841 The Alameda, Berkeley, CA 94707, and **Diane Resek**, CA. *Changing Teachers' Concept of Mathematics with the Goal of Providing Equal Opportunity for All Students to Succeed in Learning Algebra.*

Through the REvitalizing ALgebra (REAL) Project we worked with undergraduate math majors interested in teaching, graduate teaching assistants, and high school teachers to improve teaching and learning of algebra in schools with ethnically diverse populations. Over the course of this three-year NSF project we used a variety of activities with the participants. Some of these activities turned out to have more impact than others in their long-term effect on teachers' attitudes toward their students and in the observable effects in their classrooms. One of the goals of the project was to change teachers' attitudes and expectations in relation to what and how their students could learn in an algebra class. In this session we will discuss these activities, examine some examples, and discuss those that seemed to have more lasting impact and possible reasons for this. (Received September 19, 2009)

1056-H7-1450 **Lily S. Khadjavi*** (lkhadjavi@lmu.edu), Loyola Marymount University, 1 LMU Drive, Suite 2700, Los Angeles, CA 90045. *Social justice in the classroom through real-world examples.*

Data sets available online provide the mathematical community with excellent resources for studying social justice issues in quantitative reasoning and statistics courses. Such study can be conducted at a wide range of levels, from understanding graphs and data types to using hypothesis testing and regression models.

As a concrete example, traffic stop data has been collected by the Los Angeles Police Department under a consent decree with the U.S. Department of Justice, allowing students to investigate the issue of racial profiling. Although racial profiling is not legal, Gallup polls indicate that most Americans believe it is a regular police practice, for example affecting whether or not a driver is pulled over or what happens during the stop. Using records from over 600,000 stops over a year-long period, we find that racial disparities exist in both stop and search rates, and thus the possibility of racial profiling cannot be ruled out. Students can form their own hypotheses to test, often finding that the experiences of racial and ethnic groups differ in surprising ways.

The presentation will include examples of ways to use this data in classes, including where to access such data, related readings, and other resources. (Received September 22, 2009)

1056-H7-1518 **Julius Davis*** (jdavis24@umd.edu), 2226 Benjamin Building, College Park, MD 21207. *From research to mathematics curriculum development: Social Justice for African Americans in Chester Heights.*

A small number of scholars in mathematics education focus on teaching and learning mathematics for social justice. They have identified challenges to teaching mathematics for social justice that raise concerns about what mathematics students learn and the need for a social justice curriculum framework in mathematics. Using contextual data and experiences of African American middle school students from my dissertation, I use Gustein's community, critical and classical knowledge social justice framework to present some initial thoughts about developing a mathematics curriculum around a specific community context called Chester Heights. Developing this curriculum around Chester Heights seeks to provide a mathematical context for teachers and students to think about injustices around the drug epidemic, sports and entertainment industry, poor housing and schooling conditions, the large number of liquor stores, car dealerships, fast food restaurants, high rates of un-and-underemployment and debilitating businesses. I focus this work on state and school district policies that require students to take a data analysis course connected to a high stakes standardized algebra exam. This course could have students analyze data related to injustices in their specific community context. (Received September 22, 2009)

1056-H7-1558 **Deborah E Berg*** (debbie.berg@gmail.com), 118 Henzlik Hall, University of Nebraska-Lincoln, Lincoln, NE 68588-0355. *Creative Mathematics for All? A Survey of Preservice Teachers' Attitudes about Students' Capabilities.* Preliminary report.

Currently, students who do not show initial promise in mathematics rarely get the opportunity to solve non-routine problems of novel mathematical content. This presentation includes preliminary results of a survey of prospective teachers' opinions about which students should have access to problems requiring creativity and mathematical insight. It also discusses how one could prepare preservice teachers to offer such problems via a methods course and field experience. I propose that such carefully chosen problems should be available to all students, regardless of previous identification as 'gifted'. Historically, non-Asian minorities tend to be underrepresented in gifted programs. Interesting these previously unrecognized students in mathematics could lead to a greater minority presence in the field. (Received September 22, 2009)

1056-H7-1608 **Tina Alves Mancuso*** (mancut@sage.edu), Department of Mathematics, 140 New Scotland Avenue, Albany, NY 12208, and **Deborah Lawrence** (lawred@sage.edu), Department of Mathematics, The Sage Colleges, Troy, NY 12180. *Increasing the Participation of Girls in Mathematics and other STEM Fields in Higher Education.*

The Sage Colleges offers a program called Girls Excited about Engineering, Mathematics, and Computer Science (GEMS), targeted at girls at the middle and high school level. (See www.sage.edu/rsc/gems.) The over-arching goal of the program is to increase the retention of girls from middle school through high school and into college within these fields, thus addressing the issue of gender equity in mathematics and other STEM fields. The authors received funding from a private foundation to run GEMS for six years. We will describe the components of this program, its evolution to its present form, challenges faced along the way, and will present six years' worth of data demonstrating its success. (Received September 22, 2009)

1056-H7-1663 **Angel R Pineda*** (apineda@fullerton.edu). *Teaching Numerical Analysis in Cambodia.*

The International Mathematical Union has a volunteer lecturer program (IMU-VLP) in which professors teach advanced mathematics courses in developing countries. The program is designed to use education in mathematics as a form of international development. The U.S. National Committee for Mathematics (part of the National Academy of Sciences) represents the US in the IMU. One of the programs of the IMU-VLP is a masters degree in mathematics currently being taught at the Royal University of Phnom Penh (RUPP) in Cambodia. During the summer of 2009, I taught a 3-week intensive course in numerical analysis at the RUPP as part of the volunteer lecturer program supported by the U.S. National Academy of Sciences. In this talk, I will describe my experience teaching at the RUPP. (Received September 22, 2009)

1056-H7-1696 **Mouchumi Bhattacharyya**, **Christopher Goff** and **Larry J Langley*** (llangley@pacific.edu), Mathematics Department, University of the Pacific, Stockton, CA 95211. *Math and Social Issues.* Preliminary report.

Pacific Seminar II is the second semester course required of University of the Pacific students during their first year. Students complete the sequence with a third course the final semester of senior year. Pacific Seminar I offers students a common syllabus looking at the question "What makes a good society?" and related themes. The second semester consists of topical discussion oriented seminars examining one or several of the first semester themes in depth. The Mathematics department offering is Math and Social Issues. The course covers a variety of mathematics, statistics and mathematics education topics related to diversity, ecological, and other social issues. There is no mathematics prerequisite for the course. We will look at what what was successful in the course and changes we are considering for the future. (Received September 22, 2009)

1056-H7-1908 **David W. Henderson*** (dwh2@cornell.edu), Department of Mathematics, Malott Hall, Cornell University, Ithaca, NY 14853-4201, and **Kelly Gaddis**. *Algebra Project Curricula – Mathematics meaning through experience and dialogue.* Preliminary report.

The Algebra Project is a national organization is devising ways to "raise the floor" of mathematics achievement. The target population is those students performing in the bottom quartile on state and national tests. The Algebra Project seeks to stimulate a demand for math literacy in the young people themselves. The Algebra Project has developed a cohort model that we predict will stimulate and enable students to pass the mandated tests in mathematics, and to score well enough on the SAT or ACT to enter college, and place into non-remedial mathematics courses. A key component of the emerging model is the development and testing of new high school curricular materials based on common experiences, activities, and dialogues. We will describe the development of the geometry curricular materials, their base in experiential activities, and the dialogues that replace the paragraph-based text of most textbooks. We observe as an immediate effect of these materials: 1. Students are discussing their mathematical ideas with each other. 2. Students want to and enjoy reading the curricular materials and responding to the mathematical problems posed. 3. Students interact in writing with the text, actively commenting on, questioning and reacting to the mathematical meanings in their own words. (Received September 22, 2009)

1056-H7-1930 **Natasha M Speer*** (speer@math.umaine.edu), 234 Neville Hall, Department of Mathematics and Statistics, University of Maine, Orono, ME 04469. *The history, impact, and current efforts of Emerging Scholars Programs.*

Uri Treisman's Emerging Scholars Program (ESP) has a 30-year record of improving minority student achievement and retention thus enabling students to move through the calculus gate and into technical fields. This talk will include an overview of the history of ESP, impact of ESP on students, and information about current efforts to disseminate it to more institutions. Treisman studied work habits of successful and unsuccessful students and designed an instructional model where ethnically diverse groups of students worked together on challenging problems. Instructors create problem sets that require ideas from multiple chapters, fill gaps in student preparation without resorting to remediation and teach students to persevere. Unlike many retention programs, ESP was designed as an honors-level program. The results of ESPs at a variety of institutions are impressive. Qualitative and quantitative evaluations demonstrate higher average grades and graduation rates, increased persistence in calculus-based majors, and increases in numbers of minority math majors. Over the past several years, efforts have been made to further disseminate ESP and make resources available to faculty who wish to establish ESPs on their campuses. These efforts and plans for expanding them will be described. (Received September 22, 2009)

1056-H7-1932 **Josephine Davis Davis (Dr.)*** (davisj@fvsu.edu), Department of Mathematics and Computer Sci., Fort Valley State University, 1005 State University Drive, Fort Valley, GA 31030, and **Monica Mitchell** (mmitchell@qem.org), Quality Education for Minorities, 1818 N St. SW Suite 350, Washington, DC 20036. *A Pan-African Model for Developing Mathematical Talent in Africa.*

Talent identification and the development of mathematically gifted students in Africa require the commitment of African mathematicians and the global mathematics community. The breadth of the African continent, language barriers and inequitable access to quality instructional resources and trained mathematics professionals are but a few challenges confronted.

The African Mathematical Union (AMU)fosters international cooperation for cultivating mathematical talent through one of its four commissions,the Pan African Mathematics Olympiad (PAMO). PAMO sponsors annual competitions modelled after the International Mathematics Olympiad to identify African talent.

The John Templeton Foundation, via the Quality Education for Minorities (QEM), funded a Committee of Visitors (COV) to assess AMU's capacity for talent development. Site visits were made from 2006 - 2009 to Senegal, Benin and Cotonou. COV's findings and programmatic vision for broadening African talent development are herein presented. Additionally, the transfer potential of these strategies for enhancing mathematical talent among underserved students in the USA should encourage the historical addition of a minority on the USA's International Mathematic Olympiad team. (Received September 22, 2009)

1056-H7-1989 **Maura Mast*** (maura.mast@umb.edu), Department of Mathematics, 100 Morrissey Blvd, University of Massachusetts Boston, Boston, MA 02125-3393. *Teaching Mathematics and Democracy.* Preliminary report.

In this talk I'll outline my experience developing and teaching an honors course for non-math majors entitled "Mathematics and Democracy". The first half of the course focuses on the importance of mathematical and quantitative literacy for informed participation in society. We discuss the relationship between mathematics and social justice through issues such as access to quality mathematics education, how mathematics can be used to understand and critique inequity, and the role of mathematics teaching and learning in challenging the status quo and transforming society. In the second part of the course, we look at how mathematics helps us understand different aspects of society, from fair division to voting theory to game theory. (Received September 22, 2009)

1056-H7-2081 **Maria G Fung*** (mfung@worcester.edu), Mathematics Department, Worcester State College, 486 Chandler Street, Worcester, MA 01602. *A First Year Seminar on Exploring Data for Social Change.* Preliminary report.

In this talk we discuss a writing intensive first year seminar course on statistics that was centered on data that reveals social injustice issues in health care, education, and the environment: both locally (a large urban center) and globally. We also describe the social service project of this course which involves collaboration with students from an applied sociology course. First-year students and their sociology counterparts analyze data collected from community partners of the Center for Service Learning and Social Engagement at Worcester State College and they present a report of their findings. (Received September 23, 2009)

1056-H7-2127 **Elizabeth C Rogers*** (brogers@piedmont.edu), Piedmont College, 165 Central Avenue, Demorest, GA 30535. *Challenging Eurocentric Mathematics History to Encourage Understanding of Cultural Diversity in Mathematics Classrooms.*

Our cultural history helps shape our identities and every student needs to see his/her culture presented in a positive manner. Due to the traditional Eurocentric approach to mathematics, many K-12 teachers have little knowledge of the contributions of diverse societies. Mathematics has lagged behind other disciplines in understanding and forming a multicultural basis of instruction. It is this author's contention that mathematics needs to go further than use of multi-ethnic names in textbooks. Change needs to come from mathematics teachers responding to their knowledge of the mathematical contributions of the societies represented in their classrooms. This presentation will discuss the use of research, writing projects and preparation of lesson plans based on non-eurocentric mathematics history topics in classes for middle grade and high school teachers.. Examples of papers and lesson plans will be available for participants to share. Anecdotal evidence for multiple teachers' experience with these lessons will be discussed. (Received September 23, 2009)

# *Mathematics Courses for the Liberal Arts Student*

1056-J1-95 **Robert A. Blumenthal*** (robert.blumenthal@gcsu.edu), Department of Mathematics, Georgia College & State University, Milledgeville, GA 31061. *Great Ideas of Modern Mathematics: An Approach to a Rigorous Mathematics Course for the Liberal Arts Student.* Preliminary report.

One of the weaknesses of many of the courses aimed at the liberal arts student is that all too often they morph into either a math appreciation course or a math history course thereby transforming the experience into something other than a course in mathematics. Even if this situation is avoided, another pitfall is that many such courses are survey courses organized around a multitude of topics. As such, each topic receives only superficial treatment and the student misses the essential experience of delving deeply into an important mathematical theory. I have sought to avoid both of these situations and have taught for many years a course organized around a few selected topics in advanced mathematics. These topics must be chosen carefully and, in my experience, need to meet several criteria. Each topic must be one which the students have not encountered before and must represent a truly important mathematical idea. Each topic should be modern in the sense that it originated relatively recently and is an active area of continuing research. Finally, each topic must be able to be presented to the general student without loss of mathematical rigor. In this paper I will discuss some approaches and assignments related to particular topics which have worked well in this course. (Received July 26, 2009)

1056-J1-174 **James Morrow*** (jmorrow@mtholyoke.edu), Mathematics Department, Mount Holyoke College, 50 College Street, South Hadley, MA 01075. *Mathematical ways of reasoning and knowing through geometry.*

I will describe a course by which students meet liberal arts objectives by investigating geometry. My goals for the course are to provide an experience of mathematics as a distinctive way of knowing, give perspectives on mathematical reasoning, and compare ways of reasoning and knowing in mathematics to ways in other disciplines. I also try to develop students' ability to ask questions, make discoveries, and take a creative approach to solving problems.

Students begin each topic by doing mathematics. They carry out investigations, create categories, form conjectures, and ask questions. The major investigations are: a geometry walk (an exercise in observing geometry in the environment and forming categories), constructions by paper folding, ruler and compass constructions, and hyperbolic geometry constructions using geometry software. I assign readings in the book Journey into Geometries.

Students do construction work in labs and discuss mathematical systems, undefined terms, axioms, theorems, and consistency in a system of axioms. They compare mathematical systems to methods and standards of argument in the natural and social sciences, arts, and humanities. (Received August 11, 2009)

1056-J1-247 **Karen Saxe*** (saxe@macalester.edu), Dept of Mathematics and Computer Science, Macalester College, 1600 Grand Ave., St. Paul, MN 55105. *Quantitative Approaches to Problems in Democracy.*

In this talk I will give an overview of a course I teach on what might be called "Quantitative Approaches to Problems in Democracy." The course covers the mathematics behind some of the basic problems of elections and voting, and includes apportionment, redistricting, and an introduction to several electoral systems used around the world. The course is intended for future political leaders, and most students are majors in political science, or international studies. Throughout the course, topics are presented in context, and pros and cons are always debated. I will give a detailed outline of topics covered, an overview of the assignments, and share my views about why I think this is a good course for liberal arts students. (Received August 19, 2009)

1056-J1-391 **Penny H. Dunham*** (pdunham@muhlenberg.edu), Muhlenberg College, Dept. of Math & CS, 2400 W. Chew St., Allentown, PA 18104. *Symmetry and Design Portfolios Showcase Mathematics for Liberal Arts Students.*

"Symmetry and Shape" is a 100-level course that examines geometric concepts in art and nature. Its primary audience is students from the humanities. Two portfolio projects in S&S showcase mathematics found in art and everyday objects. In the first, students collect "real world" examples of symmetry using images from publications, personal photographs, the Internet, and other media. They organize the collection by symmetry type with a brief description of each item. The focus is on variety (in both symmetry types and sources) as well as correct classification. The second portfolio is a collection of original student art to illustrate mathematical concepts studied throughout the semester. Design assignments flow from work with geometric topics such as compass and straight-edge constructions, the golden ratio, Fibonacci and Pythagorean spirals, frieze and wallpaper patterns, and perspective. Students submit a short paper explaining underlying mathematical principles in each design and making a case for meeting the course goals. Finally, they display their designs in the annual campus Art Week. In this talk, I'll show examples of student work and provide grading rubrics. (Received September 03, 2009)

1056-J1-458 **G. Edgar Parker*** (parkerge@jmu.edu), Department of Mathematics and Statistics, James Madison University, MSC 1911, Harrisonburg, VA 22807. *Teaching the Nature of Applied Mathematics.* Preliminary report.

At James Madison University, a course entitled **The Nature of Mathematics** has been offered since 1985 and satisfies the General Education mathematics requirement at the university. Pre-requisite to the course is to be admitted to the university. Over its lifespan, the course, when under the author's care, has evolved into a platform (presented with varying curricula) for the students to experience axiomatics by making arguments themselves, first within their own procedural experience and then from "axioms" outside their educational experience. Providing a version that highlights applied mathematics, yet maintains the student activity level that the "pure" version affords has provided a greater challenge, but over the last decade the author has come up with such a course with which he is reasonably pleased. This talk will feature the structure of the current "nature of applied mathematics" course and highlight experiences from the applied version of the course. (Received September 08, 2009)

1056-J1-508 **Stuart Boersma*** (boersmas@cwu.edu), Department of Mathematics, Central Washington University, 400 East University Way, Ellensburg, WA 98926, and **Caren L Diefenderfer**, **Shannon W Dingman** and **Bernard L Madison**. *Teaching Quantitative Reasoning with the News.* Preliminary report.

The daily newspaper has numerous examples illustrating the need to be able to deal critically with quantitative information in today's society. Newspaper articles provide a variety of changing contexts which emphasize the relevance of quantitative reasoning in everyone's life. Additionally, being current and relevant, newspaper articles provide students with an easy answer to the question "When will I ever use this?" By carefully choosing articles and constructing meaningful study questions, an instructor can help students investigate absolute and relative change, make sense of very large (or small) quantities, and extract information from simple mathematical models. Newspaper articles can be used in a variety of effective pedagogical settings and naturally provide numerous different contexts for student exploration, review, and assessment of basic mathematical skills. Specific examples of articles, study questions, assessment instruments, and resources for teaching such a course will be presented. (Received September 10, 2009)

1056-J1-736 **Brad Bailey*** (bbailey@ngcsu.edu), 82 College Cr., Dahlonega, GA 30533, and **A. Robb Sinn**, 82 College Cr., Dahlonega, GA 30533. *Service-based learning projects in statistics courses.*

Service-based learning occurs whenever students are engaged in coursework that provides support for institutional or community projects. In this talk we describe service-based learning projects for an introductory statistics course that use real-world data that students find relevant. We give the research questions that the students addressed. Further, we describe where the data come from and how faculty at other institutions could find or generate similar data sets. We briefly outline the order in which we covered topics for the course so that students can begin and complete these projects in a timely manner. We also describe the outcomes of these projects. (Received September 16, 2009)

1056-J1-747 **Sean D Simpson*** (Sean.Simpson@sunywcc.edu). *Including Presentations as a Component in a Liberal Arts Math History Course.*

At Westchester Community College, a substantial number of non-technical majors take Development of Mathematical Thought, a course that covers different number systems, different styles of arithmetic and different styles of algebra in a historical way (such as, Babylonian division, Egyptian multiplication, Mayan numbers, etc.). Essentially, it is a liberal arts math history course. Instructors have tried a variety of options to discuss some modern mathematical figures at the end of this course. This can be rather problematic, as the prerequisite for the course is Beginning Algebra, and typically students are coming directly from that course. Along with other options, the presenter has utilized biographical oral presentations by the students. In this talk, the presenter will discuss the role of these presentations in the class, the requirements of the presentation for the students, how the talks have been received by the students and how the presentations have evolved over time. (Received September 16, 2009)

1056-J1-816 **Yu-Ju Kuo*** (yjkuo@iup.edu), Mathematics Department, 210 S. 10th St., Indiana, PA 15705. *Your Financial Future.*

LBST499 is the Liberal Studies Senior Synthesis course at Indiana University of Pennsylvania. LBST499 Your Financial Future was proposed by the author and approved in Spring 2007. This course explores different perspectives related to personal finance, prepares students with basic knowledge for their future wealth, and improves their quantitative literacy. Mathematical topics include mortgage, annuity, investment, and data analysis. Many examples and exercises are discussed with the use of individual information. In this presentation, the author will discuss the details of an analysis of personal financial status, the barter exchange, and the virtual investment project. The analysis of personal financial status utilizes the students' research on the salary level for an entry-level position in their chosen fields and students' spending records to provide them a reality check of their financial situation upon graduation. The barter exchange gives students an opportunity to experience trading through objects rather than the common exchange medium, money. The 6-week virtual investment project provides students near-real online trading experience with the focus on weekly analysis reports, rather than profit alone. Additional activities will be discussed if time permits. (Received September 17, 2009)

1056-J1-830 **Daniel E. Otero*** (otero@xavier.xu.edu), Department of Mathematics & Computer Science, Xavier University, 3800 Victory Parkway, Cincinnati, OH 45207-4441. *A New Course for Liberal Arts Math: the Mathematics of Calendars and Timekeeping.*

In an effort to provide ever more variety for how students explore mathematics in a liberal arts context, the author has experimented with a new course called The Mathematics of Calendars and Timekeeping. In this course, the history and science of timekeeping provide an environment in which mathematics is used in various ways to help organize time and its natural cycles for the benefit of societies, both ancient and modern. The clock and the calendar are familiar devices to everyone today, but few realize the mathematics that ... makes them tick! The mathematical topics in the course – most of which are new to the typical undergraduate student but technically unsophisticated nonetheless – include: comparison of decimal, sexagesimal and vigesimal numerations; elements of plane and spherical trigonometry; continued fractions as rational approximations to real numbers; the Division and Euclidean algorithms; congruence arithmetic. Much of the history of world calendars, basic planetary astronomy, and the philosophy of time is incorporated, to put the mathematical ideas in context. (Received September 17, 2009)

1056-J1-855 **Jeffery Thomas McLean*** (jtmclean@stthomas.edu), University of St. Thomas, Mail #201 OSS, 2115 Summit Avenue, St. Paul, MN 55105-1096. *Evolution of the Mathematical Sampler.*

Years ago our university reinstituted a liberal arts course called the Mathematical Sampler. Over time we have experimented with various textbooks and selections of content. Changes in university requirements and the way in which courses are scheduled required some changes in the course. This presentation addreses new writing assignments, assessment methods and project assignments, some even made during this fall semester. Included will be student reflections on the course. (Received September 18, 2009)

1056-J1-870 **James E. Hamblin*** (jehamb@ship.edu), 1871 Old Main Drive, Shippensburg, PA 17257. *Designing a "Math for Liberal Studies" Course.*

Most universities have a mathematics course specifically designed for students who do not need a technical course like calculus or statistics, but still need to fulfill a university math requirement. What topics should a course like this include? How should the class be structured? In this talk I will give an overview of the course and textbook that I am designing for Shippensburg University. (Received September 18, 2009)

1056-J1-946 **Ioana Mihaila*** (imihaila@csupomona.edu), 3801 W. Temple Ave., Pomona, CA 91768. *Fun Projects and Activities for Poets and Mathematicians Alike.*

This talk will give examples of projects and class activities used in a Math for Liberal Arts class in order to engage the students and liven up the atmosphere. The list of topics includes art, social choice, logic, music, finances, statistics, etc., and it is always open to additions. For example, during the "statistics unit", we talk about polling on sensitive issues, we work out the mathematics behind the formula and then we actually try it out in class. At the end of the class we have a Pictionary game - and the trick here is what to choose for the pictionary game cards! (Received September 21, 2009)

1056-J1-964 **Barbara L Hess*** (hess@calu.edu), Mathematics and Computer Science Department, 250 University Ave., California University of Pennsylvania, California, PA 15419. *Applications of Mathematics: Using Multi-Media Curriculum to Teach Mathematics to Liberal Arts Majors.* Preliminary report.

Many times liberal arts majors think that mathematics is just a bunch of formulas. They view mathematics as not revelant to the real world or as something that they would ever use.

ThinkSharp curriculum has been used in a liberal arts mathematics course at California University of Pennsylvania to fully engage students in doing mathematics. Video tape case study scenarios paired with delayed revelation pedagogy are used to introduce liberal arts majors to such mathematical topics as box plots, linear programming and dijkstra method of finding the shortest path. Students are split into small groups that work as problem solving teams in the on campus course. In the online version of the course, the entire class works together through online discussion threads to solve the case study scenarios.

Formal study has not been conducted but outcomes assessment has shown that students are meeting course objectives. Enrollment figures in the course have been strong and show that liberal arts students are drawn to the course because it is not the typical mathematics course. (Received September 19, 2009)

1056-J1-1034 **Caroline P Lubert*** (lubertcp@jmu.edu), MSC 1911, Dept of Math & Stat, JMU, Harrisonburg, VA 22807. *Teaching Non-Mathematics Majors using 'Group Topic Books'.* Preliminary report.

I recently taught a terminal class for non-math majors called 'The Nature of Mathematics'. The syllabus consisted of Set Theory, Logic, Mathematical Systems and Number Theory. The students were generally bright and engaged, but math is "not their thing". Having previously tried numerous ways to make the subject matter more interesting and relevant to such students, I decided to try using group topics as a way to motivate their learning. The students divided themselves into groups of four and were given a 'group topic book', which they were instructed to rotate around the group members. They then chose a 'group topic' which they would use for the rest of the semester. They could either pick one from a list I gave them (such as the Arts, Sports, Food & Drink, Nature, Science) or come up with their own. Every time we had an example of a new concept in class, they were required to get together and construct their own example, based on their group topic. In addition, they worked on a semester-long topic-based group project. I took the books in at regular intervals, and used their examples to generate 'personal' exam questions to ensure that each member of the group was contributing. The level of understanding of concepts increased dramatically through the use of this technique. (Received September 20, 2009)

1056-J1-1118 **Gerald W. Kruse*** (kruse@juniata.edu), Juniata College, 1700 Moore St., Huntingdon, PA 16652. *Using CLA in the Classroom Performance Tasks for Assessment in a Quantitative Reasoning Course.* Preliminary report.

Juniata College's MA 103, Quantitative Methods, is offered to satisfy a Quantitative skill. The goals of the course include preparing the students to be quantitatively literate, analytic problem solvers, and able to present quantitative arguments, which correspond nicely with the goals of CLA in the Classroom Performance Tasks. Performance Tasks are used in several different ways. On the first day of class, a task with a significant quantitative literacy component is given as a pre-assessment, and then on the last day, a similar task is given as a post-assessment. During the semester, three Performance Tasks have replaced the "traditional" open-ended projects used previously. These three tasks share a scenario, and are designed to be authentic, with a reasonable scenario. In this case, the students are told that they have matriculted at a small liberal arts college (similar to Juniata), and are active in student government. The tasks are aligned with the material being covered in the course, and all have a element of urgency (funding allocation, loan analysis). Preliminary data will be presented with the results on the pre and post assessments, and this data will be compared to results on the same assessment in sections using traditional projects. (Received September 21, 2009)

1056-J1-1481 **Darrah Chavey*** (chavey@beloit.edu), Beloit College, 700 College St., Beloit, WI 53511. *Ethnomathematics as an Interdisciplinary Outreach Course.*

At Beloit College, we have taught Ethnomathematics as a terminal mathematics course for liberal arts students for 14 years. We have been successful in integrating the course into the College's area studies programs, so that this course counts towards the course requirements for the Asian Studies, Latin American Studies, and African Studies minors. This cooperation was accomplished through a combination of care in balancing course topics and the inclusion of a major term project that students use to customize the course to their interests. Students have also used this course to complement interests in anthropology, religious studies, philosophy, art, museum studies, classics, and elementary education. We will discuss tactics we have used for this term project, both for the area studies minors and to reach out to other interests of students in this course. Fourteen years worth of term project ideas from four faculty members and their students have given us a wide range of suggestions for student projects, and the vast majority of our students have had substantial success in finding a project that got them excited about the course. (Received September 21, 2009)

1056-J1-1584 **Agnes M Rash*** (arash@sju.edu), Dr. Agnes M. Rash, Mathematics Department, Saint Joseph's Univeristy, Philadelphia, PA 19131. *The Whole Truth about Whole Numbers.* Preliminary report.

Mathematics requirements for the liberal arts students vary from one institution to another. The new curriculum at Saint Joseph's University requires all students to satisfy a "mathematics beauty" course requirement. Mathematics beauty courses emphasize analytical reasoning, logical argument, pattern analysis, the role of conjecture and the art and meaning of proof. Several of the faculty members have engaged in creating new courses to fulfill this requirement.

The Whole Truth about Whole Numbers is one of the newly developed courses. Topics from Number Theory that are accessible to nonmathematics and nonscience majors are used to fulfill the new requirement. The course was designed in the summer of 2009 by the author with the assistance of a senior mathematics major and is being taught in a pilot program in Fall 2009.

This talk will discuss the topics included in the course, the learning objectives, the delivery of the course content, and course outcomes including assessment of student learning and attitudes. (Received September 22, 2009)

1056-J1-1618 **Ann C Hanson*** (ahanson@colum.edu), Columbia College, Science and Mathematics Department, 600 S. Michigan, Chicago, IL 60605. *Liberal Arts Math - An Activity Based Class.*

The presenter will describe the liberal arts math course she and a colleague developed. Because many of the topics in the course are similar to the topics covered in high school, the course presents math in a slightly different manner. Instead of teaching math slower or in the same manner as in high school, a variety of hands-on activities are used to help make the math more comprehensible and to help reinforce the concepts studied. Activities for surface area, direct proportions, inverse proportions, and exponential functions will be described. (Received September 22, 2009)

1056-J1-1630 **Teresa E. Moore*** (moore@ithaca.edu), Dept. of Mathematics, Ithaca College, 1212 Williams Hall, Ithaca, NY 14850-7284, and **L. Christine Kinsey** (kinsey@canisius.edu), Dept. of Mathematics and Statistics, Canisius College, 2001 Main St., Buffalo, NY 14208. *Borrowing literary structures for mathematics lessons.* Preliminary report.

In short stories and movies, there is the concept of the story arc. Many of our liberal arts students are familiar with and appreciate this structure, but they would never dream of applying it to mathematics. Students recognize that a well-written story follows a certain internal logic, beginning with the introduction of the characters and setting, the initial conflict, various complications, and finally the resolution. We use this structure to develop engaging lessons in mathematics that students find interesting and satisfying. Discussing the intentional story line with the students after they have completed the activities helps them relate mathematics to familiar and comfortable settings. We demonstrate this structure with a sample lesson on Knots and Star Polygons – one of our favorite explorations for liberal arts students. We then discuss the mathematical and literary equivalents and student reaction to the connections. (Received September 22, 2009)

1056-J1-1668 **Manuel J. Sanders*** (mjsander@uscb.edu), One University Blvd., Bluffton, SC 29909. *Mathematics and General Education: Exposing Students to Mathematics and its Tools in the 21st Century.* Preliminary report.

The University of South Carolina Beaufort (USCB) is the newest baccalaureate degree granting institution in the state of South Carolina. All students must take at least one course in mathematics to partially fulfill the Numerical and Analytic Reasoning component of USCB's General Education curriculum accompanied by a second course in mathematics, statistics, computer science, or logic. A new mathematics course BMTH 101: Experiential Mathematics and Computation was approved by the faculty in 2008. A total of four sections have been piloted. I will discuss the tenets of the course philosophy, describe the cornerstone topics of the course and outline some non-traditional aspects of the curriculum and course activities. Preliminary assessment of course outcomes will also be discussed. (Received September 22, 2009)

1056-J1-1756 **george rublein*** (gtrubl@math.wmw.edu), Department of Mathematics, College of William and Mary, Williamsburg, VA 23187-8795. *The Mathematics of Powered Flight. The airplane course revisited.*

In the electronically updated version of "The Mathematics of Powered Flight", students simulate the navigational relationship between cockpit avionics and FAA published instrument flight maps. Harsh cross-wind landings that can be computed geometrically are illustrated with web-based views of near-accidents. Aviation weather reports from the National Weather Service announce wind and pressure information, both of which are employed in the analysis of safe landing procedures. (Received September 22, 2009)

1056-J1-1769 **Rich West*** (rwest@fmarion.edu), PO Box 100547, Florence, SC 29502. *Projects & Portfolios Motivate Most.*

Francis Marion University has a 6-credit-hour general education mathematics requirement for all students. For the non-science majors we offer a two-course sequence in modeling and problem solving. Each course requires four modeling projects and a portfolio. The projects help students put their knowledge and skills together on a real-world problem that they must present in a professional manner. The portfolio is an organized collection of their graded work that they must write a reflective summary on what they have learned in the course. Student feedback is positive for the projects and the portfolio provides a record of that. Follow-on program assessment if further facilitated by the portfolios. (Received September 22, 2009)

1056-J1-1866 **Volker Ecke*** (vecke@wsc.ma.edu), 577 Western Ave, Westfield, MA 01086, and **Christine von Renesse**, **Julian Fleron** and **Philip Hotchkiss**. *Games and Critical Thinking.*

The investigation of games can provide worthwhile material for an inquiry-based Mathematics for Liberal Arts course. For many students, exploring strategies and thinking critically about good moves is naturally motivated by their desire to play well and win (yet, we also make sure the competitive aspect does not turn off others). In addition, the absence of common triggers for math anxiety (such as formulas) allows students to give mathematical investigations a fresh second look.

We have successfully used so-called connection games—such as *Hex, ConHex, Stymie*—in our "Explorations of Mathematics" courses.

In class, we use small group and whole class discussions to consider, clarify and refine the various ideas students develop. Questions such as: Is that always the case? Will your suggestion always work, no matter what your opponent does? can lead the class into proof territory.

Beyond these investigations into strategy, the class also explores mathematical connections to large numbers, complexity, geometric tessellations, and computational tractability.

In this talk, we will share some of our materials, pedagogical considerations, and our experiences in the classroom. (Received September 22, 2009)

1056-J1-1907 **Bill Linderman*** (wclinder@king.edu), 105 Overbrook Drive, Bristol, TN 37620. *Egyptian Fractions.* Preliminary report.

The ancient Egyptians represented fractions as sums of unit fractions (fractions with numerator 1). There are many problems in this area - some unsolved and some that are quite accessible. We investigate some of the properties of Egyptian fractions and present several methods for determining their representations. (Received September 22, 2009)

1056-J1-1974 **Deborah L. Gochenaur*** (dlgochenaur@ship.edu), 38 Blair Mountain Road, Dillsburg, PA 17019-9317. *Reaching the Unreachable: Pulling Students Kicking and Screaming into a Mathematical Vortex Where They Transform to Develop Mathematical Eyes through Innovative Approaches and Activities.*

Math courses geared towards non-majors require that we become creative in finding ways to empower students to connect topics to their own life experiences - appealing to their creative selves, while also allowing them to interact with the mathematics. In our desire to draw students into the material, we need to make each student feel valued for the gifts s/he does bring to the classroom learning environment, acknowledging that those gifts lie outside of our own chosen field. This session will share several specific activities and the student feedback that was collected through classroom surveys throughout a Liberal Arts math course. Striving to get students to see math through a new lens, learning to communicate mathematically through small group work and critiquing each others' problem solving in think-pair-share mode, classroom activities were included in most class meetings. Students discuss particular assignments as well as a general atmosphere of acceptance in the way assignments were given and the course was changed to better fit their personal needs, based on survey results, as the semester progressed. A combination of personal interaction, innovative assignments, and class discussions opened students' eyes to view math in a way they had never experienced before. (Received September 22, 2009)

1056-J1-2008 **Julian F Fleron*** (jfleron@wsc.ma.edu), Department of Mathematics, Westfield State College, Westfield, MA 01086, and **Volker Ecke**, **Christine von Renessee** and **Philip K Hotchkiss**. *How to Include More of the Arts in Mathematics for Liberal Arts.*

Discovering the Art of Mathematics is an NSF supported effort to develop a library of ten inquiry-based learning guides which seek to emphasize the continuing role of mathematics as a cornerstone of the liberal arts tradition. This focus includes: the role of mathematics as an intellectual pursuit, its continuing impact in shaping history, culture, logic, philosophy, and knowledge, its status as humanistic and aesthetic discipline, and its extensive contemporary growth.

Following a brief description of our project, the audience will sample several different curricular segments and activities which have been developed. The samples will illustrate the meaningful mathematical connections with the visual arts, philosophy, literature, logic, music, dance, culture, and other areas which compel increased interest for our liberal arts students.

We will close by providing references for resources that can used selectively to supplement an existing course or can used for the basis of an entire course. (Received September 22, 2009)

1056-J1-2040 **Mairead K Greene*** (mairead.greene@rockhurst.edu). *The Mystical Math Room.*
Every fall semester, the students in Math in the Modern World at Rockhurst University experience the power that comes with discovering knowledge in a student-centered, active-learning classroom and then having the opportunity to share that knowledge with the public. The course focuses on providing students with mathematics that is relevant to their lives and exposes them to ideas that they have not previously encountered. Topics discussed in class include microfinance, fairness of voting systems and the role of geometry in modeling our world. Fifty percent of the grade in this course comes from a semester long project in which each student chooses a mathematical topic or question of interest to them and independently investigates this topic. The project is assessed through a detailed report of their investigation and conclusions, a presentation of their work to the class, and the development and presentation of an interactive experience in their area of study for visitors to the Mystical Math Room. In this presentation I will provide examples of past Mystical Math Room projects, discuss the impact of this experience on the students and share my current methods of assessing their learning. (Received September 22, 2009)

1056-J1-2055 **Daniel F Pinzon*** (dpinzon@uafortsmith.edu), 5210 Grand Ave., Math Science Building, Fort Smith, AR 72913. *Geometry and Renaissance Paintings.*
In this talk, I will discuss my experiences teaching a math course for liberal arts students in the Spring and Fall 2009. A variety of projects both new and borrowed will be discussed. I will go in depth on a project where students write about the significance of symmetries and geometrical shapes that they find in Renaissance paintings using Geometer's Sketchpad. (Received September 23, 2009)

# Mathematics Experiences in Business, Industry, and Government

1056-J5-113 **Nathaniel D Bastian*** (nathaniel.bastian@us.army.mil), 187 Columbia Hill Road, Danville, PA 17821. *A Robust, Multi-Criteria Modeling Approach for Optimizing Aeromedical Evacuation Asset Emplacement.*
The U.S. Army's Health Service Support system is designed to maintain a healthy force and to conserve combat strength of deployed soldiers by employing standardized aeromedical evacuation assets and providing a responsive field-sited medical treatment facility for the wounded soldiers evacuated from the battlefield. Since the beginning of Operation Enduring Freedom, military commanders have faced a significant combinatorial challenge integrating limited air evacuation assets into a comprehensive system for the entire combat theatre. This work describes a robust, multi-criteria decision analysis methodology using a scenario-based, stochastic optimization goal programming model that U.S. Army medical planners can use as a strategic and tactical aeromedical evacuation asset planning tool to help bolster and improve the current air evacuation system in Afghanistan. Specifically, this model optimizes over a set of expected scenarios with stochastically-determined casualty locations to emplace the minimum number of helicopters at each medical treatment facility necessary to maximize the coverage of the theatre-wide casualty demand and the probability of meeting that demand, while minimizing the maximal medical treatment facility evacuation site total vulnerability to enemy attack. (Received July 28, 2009)

1056-J5-583 **Richard D Jarvinen*** (RJarvinen@winona.edu), Department of Mathematics and Statistics, Winona State University, Winona, MN 55987. *Probability in Solutions for Assembly in Earth Orbit of a NASA Spacecraft for Travel to Mars.*
In this presentation the author provides his solution to a problem he solved during an interval while a Faculty Fellow at the NASA Johnson Space Center. In the terminology of operations research, feasible and optimal solutions are provided within a probably model dealing with the sequential assembly in earth orbit of six modules that combine to form the spacecraft for a manned round trip to Mars. A) The minimum number of launch rockets, and B) the minimum number of duplicates of each module to have on hand in order to achieve NASA reliability standards for a successful spacecraft construction need to be determined. The reliability of the launch rocket used to launch each module is an input variable in this analysis. (Received September 13, 2009)

1056-J5-750 **William P Fox*** (wpfox@nps.edu), 2977 Sloat Road, Pebble Beach, CA 93953, and **John Vesecky** and **Kip Laws**. *Using Radar to Identify Persons Carrying Wires.*

The focus of this research was to develop and test a model to show how the sensing and detection can best be accomplished with radar to detect wires on persons. Robust Detection and identification (at a safe standoff distance) of people (in a crowd) and/or animals having wires on their bodies, such as might be used to detonate explosives, is critical to the armed forces. We used radar to begin our detection process. The radar yields the range and Doppler shift history of subjects that strongly scatter radar waves because they have wires attached to them. We separate the suspects from the crowd of subjects by finding the time history of the subject(s) whose time history most closely matches the radar observation of the strongly scattering radar targets (suspects with wires), i.e. their Doppler shift (radial velocity with respect to the radar) history and position information. We develop some probabilistic models to help in finding the suspect. (Received September 16, 2009)

1056-J5-783 **James H Fife*** (jfife@ets.org), Educational Testing Service, Mail Stop 13-E, Rosedale Road, Princeton, NJ 08541. *Scoring line of best fit test questions.*

A test question might ask a student to plot a line that models a set of data points. The response is to be scored based on how close the line is to the line of best fit, defined as the line with minimum root mean square deviation (RMSD). "Closeness" is measured as the relative difference between the RMSD of the response line and the RMSD of the line of best fit. A cut point is established, and a response receives credit if the relative difference for that response is less than the cut point. Calculating the RMSD, however, can be complicated. The calculations can be simplified by plotting, in $mb$-space, the values of $m$ and $b$ for which the relative difference of the line $y = mx + b$ is less than the cut point. This region is elliptical and can be approximated as the region between two parabolas. Thus, bounds can be given on $m$ and $b$ that determine acceptable responses, where the bounds on $b$ are quadratic functions of $m$. (Received September 17, 2009)

1056-J5-788 **Candice Rockell*** (crockell@odu.edu), Old Dominion University, Department of Mathematics and Statistics, Norfolk, VA 23529, and **Dr. John Tweed**. *A Green's Function Technique for Radiation Transport in Three Dimensions.*

In the near future, astronauts will be sent into space for longer durations of time compared to previous missions. The radiation that they will be exposed to, which includes Galactic Cosmic Rays (GCR) and Solar Particle Events (SPE), is of great concern to the health and wellness of these astronauts. A study of the mathematics behind radiation transport through shielding materials will be described where the equation of interest is the Boltzmann equation. By making use of the continuous slowing down approximation, the Boltzmann equation is transformed into a Volterra integral equation, which is then solved by the Neumann series method. This solution consists of a series of Green's functions. At this time, we will address the Zero Order and First Order Green's functions which model the primary ion flux and first generation fragment flux respectively. The rest of the Neumann Series will be approximated using a non-perturbative approach. (Received September 17, 2009)

1056-J5-811 **Mike O'Leary*** (moleary@towson.edu), Department of Mathematics, Towson University, Towson, MD 21234. *Searching for the home base of a serial criminal.*

We have developed an algorithm that can estimate the location of a serial criminal's home base based on the locations of the elements of the crime series. This algorithm has been implemented in software, and provided to police agencies for use in their investigations. We shall describe the underlying mathematical approach to the problem, demonstrate the software tool, and discuss open questions. (Received September 17, 2009)

1056-J5-1384 **Robert K. Henderson*** (rkhenderson51@yahoo.com), 74 Tiburon Drive, Austin, TX 78738. *An Alternative Distributional Model for Control of Process Particle Counts in the Semiconductor Industry.*

Process control plans for particle or defect count distributions have historically been based on the assumption of an underlying Poisson distribution adequately describing the observed process data. However, it has been observed that particle and defect count distributions for semiconductor processes commonly have a heavier high end tail than what can be accounted for using a Poisson model. Previous work has suggested the use of an exponential distribution as more appropriate distributional model for wafer particle or defect counts; however, this model is a special case of a gamma distribution with a coefficient of variation set equal to one. This paper will explore the use of gamma distributional models in evaluating wafer count parameters, specifically considering approaches to determine if use of such a model is appropriate for a given process and how to establish reasonable process control plans for such processes using either traditional single-point beyond an upper control limit, or a sequential process control rule. (Received September 21, 2009)

1056-J5-1600 **Sonja Sandberg*** (ssandberg@framingham.edu), 100 State Street, Framingham, MA 01701. *The US blood supply, bioterrorism and mathematics.*

Recent concern about bioterrorism has abated as worry about the economy and swine flu has taken over people's thoughts. Nonetheless, bioterrorism is still a real threat. In the case of a smallpox bioterrorism event, the 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. One consequence of a vaccination program is the loss of blood donors due to a deferral period of 21 days following vaccination.

A mathematical model was developed to explore various scenarios to predict the impact of the 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 would have a serious deleterious effect on the blood supply. Implementing both increased donations and reduced use would 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, 2009)

1056-J5-1711 **Erich Kreutzer*** (erkreutzer@davidson.edu), Box 6625, Davidson, NC 28035-6625. *Movie Recommendation Systems.*

In 2006 Netflix, an online movie rental company, started the Netflix Prize. This was a challenge to create an algorithm that would predict what a particular user would rate a given film using only the information in a dataset of over 100 million ratings from 480,000 users. If one were to improve upon Netflix's algorithm by 10%, then he or she would receive a $1 million prize. This talk will discuss research that started with the Netflix prize and then branched out towards movie clustering and ranking. Further, another question arose that deals with newly released films. Given a past viewing history, is it possible to suggest which new film may be of interest to them? This presentation will discuss mathematical ideas on both research questions. In particular, the talk will focus on mathematical approaches that are accessible at the undergraduate level. (Received September 22, 2009)

1056-J5-1727 **Dervis Bayazit*** (dbayazit@math.fsu.edu), 3219 Post Woods Drive, Apt -D, Atlanta, GA 30339, and **Craig A Nolder** (nolder@math.fsu.edu), FSU Mathematics, 208 Love Building, 1017 Academic Way, Tallahassee, FL 32306. *Calculating the Greeks via Malliavin Calculus for Variance Gamma Process in Poisson-Wiener Space*

The main objective of this work is to calculate the Greeks of European style option contracts in finance using the Malliavin calculus when the market is modelled by an exponential Variance Gamma process. In order to do that we evaluate the corresponding Malliavin weight in Poisson-Wiener space. We measure the performance of the results of this approach in terms of the analytical results that we obtained by the inverse Fourier transform method. Also, we compare the results of Malliavin approach with the usual finite difference method. We observe a better convergence in the Malliavin approach especially for options with discontinuous payoff.

**Key words**: Malliavin calculus, Monte-Carlo simulations, Varince Gamma process, sensitivity analysis, Fast Fourier Transform methods. (Received September 22, 2009)

1056-J5-1736 **Richard J Cleary*** (rcleary@bentley.edu), 12 Lafayette Circle, Wellesley, MA 02482. *Statistical Inconsistency in the Audit Risk Model.* Preliminary report.

The Audit Risk model is used to help practicing accountants quantify the probability that the financial statements of a client will contain a significant error, known in the field as a material misstatement. While conceptually helpful, the most commonly used form of the model fails to address two important questions. First, it does not make clear whether terms in the model are independent. Second, it ignores one major possible source of error. We present data that show that auditing students interpret the model in very different ways. (Received September 22, 2009)

1056-J5-2085 **Carla D Martin*** (martincd@jmu.edu), Department of Mathematics & Statistics, MSC 1911, James Madison University, Harrisonburg, VA 22807. *Why companies need mathematicians even during rough times.*

Working in the quantitative methods division for a large consulting firm gave me many opportunities to apply mathematics in unique ways. Although clients were from both the private and public sectors, most of my time was devoted to the public sector.

I will therefore describe some interesting projects that involved mathematical modeling for the U.S. Government. In particular, a project for the Department of State involved building a model to estimate the total amount of land owned throughout the world. These results were presented before Congress. Another project for the National Highway Traffic Safety Administration (NHTSA) entailed an in-depth study on how drivers respond to anti-lock brakes. Several other projects will be mentioned that included work for the Immigration and Naturalization Service (INS), U.S. Treasury Department, and the U.S. Postal Service.

The projects I will describe were completed by teams with all levels of experience from Bachelor's degree to Ph.D. Therefore, this talk should be helpful for undergraduates interested in business, graduate students considering non-academia, professors advising students on opportunities in mathematics, or other professionals with an interest in business and government. (Received September 23, 2009)

# Mathlets for Teaching and Learning Mathematics

1056-K1-119 **Shirley B. Gray*** (sgray@calstatela.edu), 5151 State University Drive, Los Angeles, CA 90032-8204. *National Curve Bank.*

The National Curve Bank is an international database for all kinds of curves and surfaces. Intended as a resource for both students and teachers, it strives to provide features - for example, animation and interaction - that a printed page cannot offer. If you have a favorite animation, you are welcome to make a deposit. Visit the National Curve Bank at http://curvebank.calstatela.edu . We especially encourage student projects.

The NCB now has an annual award of $250 for the best deposit of the year. Recent entries submitted by both faculty and students have come from as far away as Germany, Greece and Korea. The current 2009 competition features streaming videos on various types of series, images of original sources in the Huntington Library and investigations in the number theory of Ruth-Aaron pairs from baseball.

The NCB has been blessed to have the riches of the Burndy Collection added to the already impressive holdings in History of Mathematics at the Huntington Library in San Marino, California. Mathematicians and scientists should plan to include this stop on a trip to Southern California. Come to my session to find out about works in progress on the web and pick up a free History of Math poster. (Received July 28, 2009)

1056-K1-150 **Joanne C Caniglia*** (jcanigl1@kent.edu), Room 401 White Hall, Kent, OH 44240. *A Picture is Worth a Thousand Words in Geogebra.*

GeoGebra is dynamic mathematics software, created by Markus Hohenwarter for all levels of education that bridges arithmetic, geometry, algebra and calculus. On the one hand, GeoGebra is an interactive geometry system. You can do constructions with points, vectors, segments, lines, and conic sections as well as functions and change them dynamically afterwards. On the other hand, equations and coordinates can be entered directly. Thus, GeoGebra has the ability to deal with variables for numbers, vectors and points, finds derivatives and integrals of functions.

One feature of Geogebra that is often overlooked is the ability to show real-life applications through the insertion of pictures on the coordinate grid. Teachers can import pictures of all types of functions and mathematical concepts and join the mathematics with the application. This session will explore five such applications including: conic sections, symmetry, slope, Golden Ratio proportions, and predictions of trend lines. (Received August 04, 2009)

1056-K1-189 **H. Smith Risser*** (hrisser@mtech.edu), 1300 W. Park, Butte, MT 59701. *Linear programming with mathlets.*

Applets created with Geogebra that allow students to practice concepts from linear programming will be presented. These applets can be used in high school algebra courses or in lower level college courses. (Received August 13, 2009)

1056-K1-302 **David B Posner*** (dposner@sbcglobal.net). *Number Lab: Experiencing Numbers.*

Number Lab is an on line laboratory for illustrating, exploring, and explaining the meanings and properties of number. It is addressed to students and teachers of elementary mathematics. (Received August 31, 2009)

1056-K1-907 **Paul E Seeburger*** (pseeburger@monroecc.edu), Monroe Community College, 1000 E. Henrietta Rd., Rochester, NY 14623. *Dynamic Visualization Tools for Multivariable Calculus.* 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 (or 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, etc. A series of assessment/exploration activities has also been designed to help students "play" with the 3D concepts themselves, and to assess improvements in geometric understanding gained from these activities. The results of the first year of this assessment will be shared. (Received September 18, 2009)

1056-K1-1272 **Elisha Peterson*** (elisha.peterson@usma.edu), MADN-Math, United States Military Academy, 646 Swift Road, West Point, NY 10996. *Multivariable Calculus Java Applets with Blaise.* Preliminary report.

This talk will feature several Java mathlets created using Blaise, a collection of utilities developed by the author for visualizing and exploring mathematics. The emphasis will be on mathlets that help students to visualize sometimes difficult concepts such as the divergence and curl of vector fields, the Fundamental Theorem of Line Integrals, Green's Theorem, Stoke's Theorem, and the Divergence Theorem. We will also discuss the process of creating applets with Blaise, and how the mathlets have impacted students' understanding of these topics. (Received September 21, 2009)

1056-K1-1474 **Tibor Marcinek*** (marci1t@cmich.edu), 117 Pearce Hall, Central Michigan University, Mount Pleasant, MI 48859. *Geometric Constructions as Interactive Java Applets with Feedback Feature.*

The ability of exporting dynamic geometry constructions into html pages with embedded interactive applets numbers among standard features of current dynamic geometry software. In the presentation, we will focus on a unique type of Java applets, called construction assignments, that provide immediate feedback after solving the assignment (”Well Done!” message). Such assignments can be designed and generated in a Java-based, open source dynamic geometry software Compass and Ruler (C.a.R.) and we will briefly describe various options of the final design of applets. Participants are encouraged to bring their Internet-enabled laptops as we will demonstrate the feedback feature using simple, puzzle-like assignments. We will also provide several classroom vignettes from geometry courses for teachers to discuss the educational potential and consequences (positive as well as negative) of the automatic direct feedback that applets provide.

A selection of construction assignments (that will not be included in the presentation) created by the author can be accessed at http://www.marcinek.sk/cmich/java . (Received September 21, 2009)

1056-K1-1486 **Sarah L Mabrouk*** (smabrouk@framingham.edu), Framingham State College, 100 State Street, P.O. Box 9101, Framingham, MA 01701-9101. *Hypothesis Testing: Tools for Exploration and Practice.*

Whether one uses a classical approach or a p-value approach, learning to draw conclusions for hypothesis testing requires practice. While comparing these values may seem clear for some, combining the comparison of values with a graphical representation is very helpful for others. To help students to gain a better understanding of the values that they compare as well as to provide the related graphical representation, I created tools for exploring hypothesis testing that allow students to practice drawing conclusions while providing guidance in the form of hints and correction. Using these tools, students can explore both the classical approach and the p-value approach as well as view the values of the test statistic, the critical value, the probability associated with the test statistic, and the level of significance that they use. These tools, created using MS Excel, are internet-independent, easily distributed via email or downloaded from a web site, and can be used for classroom demonstrations, for concept exploration, and for projects and assignments as well as to provide additional practice exercises. In this presentation, I will discuss and demonstrate the features of these tools as well as student reaction to their use in my traditional and online classes. (Received September 21, 2009)

1056-K1-1499 **R. Alexander Milowski*** (alex@milowski.com), 250 Granville Way, San Francisco, CA 94127. *Graph2D: An Interactive Graphing Library using the HTML Canvas.*

HTML 5 officially codifies the HTML canvas element now available in a number of web browsers. The canvas element provides an API to Javascript for 2-dimensional drawing and rendering of text. This talk will demonstrate the use of the HTML canvas as a ”mathlet” to provide interactive graphing using a library written by the author.

The process of constructing and using the library has been reduced to a simple ”microformat” that educational content authors can use to construct interactive graphs on their web pages. By a simple inclusion of the Javascript libraries, the descriptions are turned into an interactive graph with zooming, panning, and axis controls. Some feedback from use in a classroom setting and on the desktop and mobile browsers will be presented. (Received September 22, 2009)

1056-K1-1532 **Tim Chartier*** (tichartier@davidson.edu), Department of Mathematics, Davidson College, P.O. Box 6908, Davidson, NC 28035. *Google-opoly.*

You submit a query to Google and the search engine quickly returns an ordered list of pages. The page listed first is considered, loosely speaking, the best web page related to your query. In this talk, the PageRank algorithm, as proposed by Google's founders Larry Page and Sergey Brin, will be computed through its formulation as a Monte Carlo simulation. In particular, a game called "Google-opoly" will be introduced that teaches the fundamental concepts in the PageRank algorithm through a series of interactive applets. Through the game, issues of dealing with dangling nodes and cycles will be encountered and motivate the need for teleportation. In the end, computation via Markov Chains will also be discussed. (Received September 22, 2009)

1056-K1-1588 **Nathan Carter** (ncarter@bentley.edu), Department of Mathematics, Bentley University, 175 Forest St., Waltham, MA 02452, **Paul F Christiano**, Random Hall, 290 Massachusetts Ave., Cambridge, MA 02139, and **Kenneth G Monks*** (monks@scranton.edu), Department of Mathematics, University of Scranton, Scranton, PA 18510. *The Lurch Project: Validation on Demand.* Preliminary report.

We report on the current status of the *Lurch* project, a mathematical word processor capable of validating the steps of the user's work. We illustrate the concept of "validation on demand," which allows students to write mathematics, then request certain portions of it be checked for validity. Supported in part by NSF grant #0736644. (Received September 22, 2009)

1056-K1-1741 **Karl-Dieter Crisman*** (karl.crisman@gordon.edu). *Mathlets for Visualizing the Geometry of Numbers.*

Many topics in undergraduate number theory, such as multiplication tables in modular arithmetic, can be explored well with geometric visualization. The proofs of many non-geometric theorems can also gain clarity from such presentations, but usually one is presented with a single picture or must laboriously create one's own variants.

These include Gauss' Lemma in the proof of quadratic reciprocity, the asymptotic behavior of the $\tau$ and $\sigma$ divisor functions, and generation of solutions to Pell's equation. Consistently presenting these topics in the style of Minkowski's geometry of numbers brings continuity and added insight for students through an entire semester of upper-level number theory.

In this talk, we present interactive mathlets, which require only a web browser for both students and teachers, demonstrating well-known geometric proofs of these non-geometric theorems. The computer system used is Sage; they should all be easily portable to Mathematica or Maple as well. (Received September 22, 2009)

1056-K1-1810 **Susan L. Addington*** (saddingt@csusb.edu), Math Dept., CSUSB, 5500 University Pkwy., San Bernardino, CA 92407. *Retrieving old mathematics with new technology.*

Marshall McLuhan noted that a new technology often *retrieves* things which were previously obsolete. This talk presents online mathlets that support a book in progress, by David Dennis, on the history of our secondary math curriculum.

Old mathematics is difficult to understand because mathematicians thought differently then, and because communication technologies were different. For example, Euclid's and Apollonius's work was in written form, but without algebraic symbols and without diagrams. This mathematics is much more understandable with 2D and 3D dynamic geometry.

The work of John Wallis was key in the development of the calculus. However, his work uses tables of characteristic ratios rather than algebraic integrals. Wallis' work becomes much clearer with interactive tables linked with dynamic geometry.

The mathlets are mostly in GeoGebra, with a few in Cabri 3D. GeoGebra is a dynamic mathematics program that features linked geometry, algebra, and a spreadsheet. It is easy to create geometry with a mouse. More complicated sets of geometric objects can also be created by small programs in the input bar. Because GeoGebra is written in java, mathlets appear on the web exactly as designed. (Received September 22, 2009)

1056-K1-1966 **Doug Ensley*** (deensley@ship.edu), Department of Mathematics, 1871 Old Main Drive, Shippensburg, PA 17257, and **James Hamblin** (jehamb@ship.edu). *Applets for Discovery and Assessment in Math for Liberal Studies.*

The authors recently completed a suite of applets to supplement and complement a new text for the Math for Liberal Arts course at Shippensburg University. There were two major goals for this project: create intuitive, simple applets with uniform appearance and user interface; and create applets that allowed for discovery learning as well as self-assessment by students. Ideally, the self-assessment applets could be tied into the grade book for a course management system – we will discuss some of the difficulties and opportunities with this additional objective. The two dozen applets cover topics including voting theory, cryptography, check digits, bin packing, scheduling, and graph theory algorithms. (Received September 22, 2009)

# My Most Successful Math Club Activity

1056-K5-455 **Tom Thompson*** (thomth@wallawalla.edu), Department of Mathematics, Walla Walla University, 204 S. College Ave., College Place, WA 99324. *Digital Scavenger Hunts.*

A perennially popular math club activity at WWU is a digital scavenger hunt. We will provide examples of a couple of our previous "clue sheets" along with a short PowerPoint presentation of some student "responses." Event logistics including rules, transportation, after-the-hunt activities, and future directions will be discussed. (Received September 08, 2009)

1056-K5-639 **Pamela A Richardson*** (richarpa@westminster.edu), Department of Mathematics and CS, Westminster College, New Wilmington, PA 16172, and **Natacha C Fontes-Merz** (fontesnc@westminster.edu), Department of Mathematics and CS, Westminster College, New Wilmington, PA 16172. *A Revamped Problem-Solving Competition.* Preliminary report.

The annual meeting of the Allegheny Mountain Section of the MAA has included a student puzzle competition for several years. In 2009, with a little help from the faculty, a Puzzle Czar, a new format, and some great prizes, the competition was transformed into a successful event that could be scaled to fit different institutions. In this talk, we will discuss the details of the new format, what we found to be particularly effective, and what we still want to accomplish. (Received September 15, 2009)

1056-K5-684 **Ruth Favro*** (favro@ltu.edu), Math & Comp Sci Dept, 21000 W. Ten Mile Rd, Southfield, MI 48075. *Lawrence Tech's best Math Club events.*

Two events stand out. One was an Euler Day Symposium in 2007, where students gave 10-minute talks on any aspect of Euler's work, with faculty judges and prizes. The other was a Hackenbush tournament where teams of two competed in this combinatorial game (also with prizes). Strong student leadership is an ongoing work in progress. (Received September 15, 2009)

1056-K5-1587 **Ryo Ohashi*** (ryoohashi@kings.edu), King's College, Department of Mathematics, Wilkes-Barre, PA 18711. *The most engaging activity in Mathematics/Computer Science Club.* Preliminary report.

All mathematics major students must take a proof writing course in their first semester at King's College. As a part of the course, the students in the class have to create their own axiom systems as their final project, and they should make up several original theorems based on their axioms, which may be still clumsy statements and/or proofs. The most successful activity is that the club encourages the students to rework and refine the projects designed during the proof writing course in their first semester. Then, their original axiom systems are presented to students and faculty members at mathematics colloquium sponsored by Math/CS club. Those students have an opportunity to learn a public presentation skill and can experience organizing a professional seminar through the activity. In addition, some of the students present their axiom projects at a local MAA meeting each year. A reader may wonder how the process works. In this talk, I will explain how to carry out this unique but successful activity. In fact, you will see some of the students' work to feel an idea of our activity. (Received September 22, 2009)

1056-K5-1627 **Tracii Friedman***, Mesa State College, Department of Mathematics, 1100 North Avenue, Grand Junction, CO 81501. *Math Extravaganza!*

The Math Club at Mesa State College is a highly energetic and engaged group comprised of about 10-15 students. The club members organize social events, fundraisers, and other meetings designed to be math-centered (though sometimes loosely) and a lot of fun. This talk will focus on our club's foremost event, Math Extravaganza!. This event brings regional high school students to the college for an exciting day of mathematics. The Math Club students help to create and design hands-on mathematics sessions that highlight topics not usually taught in the high school curriculum (topology, non-Euclidean geometry, and robotics, to name a few). Math Extravaganza!, now in its 12th year, has been hugely successful, drawing approximately 100 high school students from about 6-8 area high schools. It also draws the eager assistance of about 35 additional college students, some of whom become regular club members after participating in Math Extravaganza!. In this talk, we will discuss the key elements that have made Math Extravaganza! such a success; we will also share some of our top ideas for fundraisers that help to support this event. (Received September 22, 2009)

# *Online Homework—Innovation and Assessment*

1056-M1-35 **Nathan M. Wodarz*** (nwodarz@uwsp.edu), Department of Mathematical Sciences, University of Wisconsin - Stevens Point, Stevens Point, WI 54481. *An Interactive Approach to Discrete Math Using WeBWorK and Flash Applets.* Preliminary report.

Discrete math problems for the WeBWorK online homework system are not easy to find, not least because of the difficulty of writing reasonable problems involving topics central to the curriculum, such as trees and other graphs. We will report on a program to develop a library of discrete math problems using WeBWorK's newly-implemented ability to embed Flash Applets. These applets could also be usable outside WeBWorK, enabling an interactive environment for student exploration. (Received July 07, 2009)

1056-M1-228 **Adam R. Lucas*** (arl3@stmarys-ca.edu), San Francisco, 94115. *Using WeBWorK, A Web-Based Homework Delivery And Grading System, To Help Prepare Students For Peer Instruction.*

As an instructor who commonly devotes as much as a third of class time to i-clicker use and peer instruction, it is essential for me to cut down on time spent transferring information. To cover topics in sufficient depth I require students to carefully read the textbook before coming to class. To help them focus on key points in the reading and track their progress, I use WeBWorK, a system of online exercises. In this study I investigate the benefits and challenges of using WeBWorK in a lower division Introduction to Programming class and an upper division Probability and Statistics class. In the lower division class, WeBWorK significantly improved peer instruction performance and resulted in students reading on average 45% longer. WeBWorK and i-clicker scores correlate well with other measures of learning and provides early warning signs of students having difficulty. (Received August 17, 2009)

1056-M1-267 **Michael E McDaniel*** (mcdanmic@aquinas.edu), 1607 Robinson Road SE, Grand Rapids, MI 49506. *Geometry on a wiki.* Preliminary report.

Collaborative homework has become an important source of instruction in an online geometry course at Aquinas College. We will see how to capture the discussions and debates of a good math class on a wiki. The wiki has influenced the structure of the course. Copyright, maintenance, rigor and assessment concerns will be addressed. (Received August 23, 2009)

1056-M1-298 **H Smith Risser*** (hrisser@mtech.edu), 1300 W. Park, Department of Mathematical Sciences, Butte, MT 59701. *The relationship between online homework, test grades, and persistence in calculus.*

Approximately 150 students in three sections of Calculus that utilized an online homework system were studied. Relationships between the completion of online homework assignments and both test grades and persistence in the course were found. Students that completed the homework assignments received significantly higher grades on tests than students that did not. Students that successfully completed a calculus course (defined as receiving a C or better) also completed a significantly higher percentage of the homework they attempted than those that did not successfully complete the course. (Received August 26, 2009)

1056-M1-324 **Laurie Lenz*** (Laurie.Lenz@marymount.edu). *The Effect of an Online Homework System on Student Outcomes in a First Year Mathematics Course.*

Online homework systems are being utilized in many college mathematics classrooms. Do these systems have an effect on student outcomes? This study compares student outcomes in multiple sections of a required mathematics course. The sections differed only in the homework method: online, traditional pencil and paper, or a combination of the two. Among other results, it was found that students were more likely to attempt and to receive higher homework grades with online assignments than with traditional assignments. However, the study found no significant difference in the exam grades of students in the sections using online homework and the students in the sections using traditional homework. These and other findings are presented in this paper. (Received August 28, 2009)

1056-M1-367 **Denise J LeGrand*** (djlegrand@ualr.edu), UALR MATH Department, 2801 S University Ave, Little Rock, AR 72204. *WebAssign: "It's How Math Homework is Done!".* Preliminary report.

How to make homework an effective learning tool is a current question that we need to answer. The options for teaching and learning Mathematics online are increasing steadily. I have found WebAssign, an online homework system, to be an indispensable part of my online Calculus course. Besides using WebAssign for regular homework, I have found that mixing it in with Maple projects and also as tutorials and short reviews have contributed to student retention and better grades. When setting up assignments, I have separated exercises into tutorials for each section. They include 2 or 3 WebAssign tutorial problems which take a student step by step through the essential concepts and may include videos. Before working the actual WebAssign assignment the student can work these as practice. Each week I cover 2 sections and set the course up as a MWF class. After every 2 or 3 sections, I have set up a review in WebAssign for those sections as a whole class period. I have also included WebAssign problems as an introduction problem in Maple labs. The Maple labs are tied to real life applications. I will show how I use WebAssign, my policies, as well as the advantages and lessons learned from my experience using this online homework system. (Received September 02, 2009)

1056-M1-539 **Edward D Smith*** (edward.smith@pima.edu), 2202 West Anklam Road, Tucson, AZ 85745. *Communicating through Online Assessment.* Preliminary report.

Most often instructors feel a disconnect with their online audience. The communication in the classroom has not been easily transfered in the virtual world when implementing online assessments. I will demonstrate techniques to improve the communication of the mathematical understanding through online assessments. (Received September 11, 2009)

1056-M1-585 **Michael E. Gage*** (gage@math.rochester.edu), Department of Mathematics, University of Rochester, Rochester, NY 14627. *Embedding applets into WeBWorK questions.* Preliminary report.

Embedding applets into WeBWorK on-line homework questions can improve their educational effectiveness since students interact with them in a more focused way. Applets can also extend the presentation and input capabilities of WeBWorK. I'll describe the current capabilities of the WeBWorK applet API which facilitates embedding flash, java and Geogebra applets into WeBWorK questions so that they operate reliably across platforms and browsers. (Received September 13, 2009)

1056-M1-703 **P. Gavin LaRose*** (glarose@umich.edu), University of Michigan, Department of Mathematics, East Hall, 530 Church St., Ann Arbor, MI 48109-1043. *The Impact of Implementing Web Homework in Calculus II.*

In this study we examine the introduction of on-line homework to a Calculus II course as a replacement for ungraded pencil-and-paper homework assignments. The on-line homework is considered in both "graded" form (in which it was counted as a small part of the students' grades) and when it is "ungraded." We examine how this had an impact on students' performance in the course, on student behavior in completing the assigned work, and on student attitudes toward the homework. We find that students working homework on-line appear to do no worse in the course than those with pencil-and-paper homework, and may do better. More significant, as expected, is counting the homework in the course grade, which results in students paying greater attention to the homework. In addition, there is some evidence that this greater attention results in students' better understanding of what they are doing on the homework and the benefit they accrue by completing it. There is also evidence that the on-line homework affords instructors greater flexibility in their management of in-class time. (Received September 16, 2009)

1056-M1-832 **A. Serpil Saydam*** (saydam@ulm.edu), University of Louisiana at Monroe, Department of Mathematics and Physics, Monroe, LA 71209, **A. Dale Magoun** (magoun@ulm.edu), University of Louisiana at Monroe, Department of Mathematics and Physics, Monroe, LA 71209, and **Charlotte H. Owens** (owens@ulm.edu), University of Louisiana at Monroe, Department of Mathematics and Physics, Monroe, LA 71209. *A Successful Approach in Designing Online Courses for Freshman Mathematics Courses.* Preliminary report.

This talk will focus on challenges and strategies in designing online courses for developmental mathematics, college algebra, trigonometry, and elementary statistics with a course management and software system. The presenters will discuss faculty training, student readiness, student-faculty interaction, and quality matters. (Received September 17, 2009)

1056-M1-975 **William H Rybolt*** (rybolt@babson.edu), Babson College, Math/Science Division, 231 Forest Street, Babson Park, MA 02457-0310, and **John D McKenzie** (mckenzie@babson.edu), Babson College, Math/Science Division, 231 Forest Street, Babson Park, MA 02457-0310. *Assessing the Impact on Student Learning and Behavior in a First Applied Statistics Course by Innovative Use of Three Delivery Types Including Online Homework: Experimental Design and Implementation.*

We conducted an experiment during the spring of 2009 to assess the merits of different methods of administering homework in an introduction to applied statistics course. The experiment employed a cross-over design involving two different instructors each teaching two sections of the course. Each student was given three different types of homework: paper, MyMathLab online with immediate feedback, and MyMathLab online with delayed feedback. At any given time half of the students were doing paper homework; the others one of the two online types. On the three exams, all students were given several common questions. By the end of the semester for each student we had demographical background data and performance results on the homework and common exam questions as well as other aspects of the course. Survey responses concerning their experience with and attitude towards different types of homework were also collected. After describing implementation of the design, we conclude with the practical difficulties encountered, our coping mechanisms, and how we benefited from previous experiments. In the next paper we give initial results and explain its impact on future homework choices. (Received September 19, 2009)

1056-M1-976 **John D McKenzie*** (`mckenzie@babson.edu`), Babson College, Math/Science Division, 231 Forest Street, Babson Park, MA 02457-0310, and **William H Rybolt** (`rybolt@babson.edu`), Babson College, Math/Science Division, 231 Forest Street, Babson Park, MA 02457-0310. *Assessing the Impact on Student Learning and Behavior in a First Applied Statistics Course by Innovative Use of Three Delivery Types Including Online Homework: Initial Results.*

This paper describes the results obtained from an initial analysis of an experiment performed during the Spring 2009 Semester in an introduction to applied statistics course. The experiment dealt with administering three types of homework: paper, MyMathLab online with immediate feedback, and MyMathLab online with delayed feedback. The details of the experimental design and implementation are described in the previous paper. The principal hypothesis addressed is whether homework type affects student learning as measured by exam performance, taking into account student and course demographics. Among the other hypotheses considered is whether there are short-term or long-term effects, again after taking into account demographics. We report on the results of statistical tests performed on all of these hypotheses. A summary of the students' attitudes and preferences towards the three homework types is provided. We conclude with a brief discussion of how to best utilize the different types of homework to enhance and assess the educational experience. (Received September 22, 2009)

1056-M1-1066 **Lisa Townsley*** (`townsley@math.uga.edu`), University of Georgia Dept of Mathematics, Boyd GSRC, Athens, GA 30602, and **Edward Azoff** (`azoff@math.uga.edu`), University of Georgia Dept of Mathematics, Boyd GSRC, Athens, GA 30602. *Using WebAssign for Uniform Assessment in Precalculus, 1300 Students at a Time.*

The University of Georgia Department of Mathematics has used uniform assessment across $> 30$ sections of precalculus each term for more than 20 years. Homegrown tutorials and software has evolved into the use of WebAssign for homework, quizzing and testing.

With more than 2000 students in Precalculus each calendar year, and various instructors including graduate students teaching the sections, it became necessary to use some uniform assessment procedures to insure that the student earning 'B' (or 'C' etc) in one section had the same skills as similarly graded students in other sections. Now teachers adhere to a strict calendar, providing lectures and in-class feedback to students, while the homework, quizzes, and tests are administered online through WebAssign. The authors will present an overview of the methods of assessment and some idea of the material available for the user interested in using online work for more than homework. We also have some data on tracking success of our students via their placement test scores, precalculus grades and subsequent course grades to measure the effectiveness of our precalculus course. Finally, we have ideas and practices for identifying students at risk and helping them find avenues to better understanding of the mathematics. (Received September 21, 2009)

1056-M1-1141 **W. Ted Mahavier*** (`wtm@mathnerds.com`), 155 Manor, Beaumont, TX 77706, and **Valerio De Angelis** and **Kyehong Kang**. *MathNerds and Webwork: a free, supervised tutoring system for online homework.* Preliminary report.

MathNerds Mentoring Networks are free on-line learning communities consisting of university students (math majors, math club members), a university professor (a mathematics educator, mathematician, or math club advisor), a school district teacher, and that school teacher's class. The networks route questions from the school district students to the university students, providing free support to the school district while giving the university students an opportunity to strengthen their communication and mathematical skills. For mathematics clubs, networks may serve as a community service. For mathematics education classes, networks may expose future teachers to the types of questions that their students may be expected to ask. Recently, MathNerds has partnered with WebWork to create networks supporting classes using WebWork's on-line homework system wherein questions about Webwork homework problems are routed to math tutors at a University Math Lab, with MathNerds volunteers monitoring the tutors' answers. (Received September 21, 2009)

1056-M1-1163 **Vicki J Roth*** (vicki.roth@rochester.edu), 107 Lattimore Hall, P.O. Box 270359, University of Rochester, Rochester, NY 14627, and **Flora McMartin**. *The "Third Wave" of WeBWorK Assessment.* Preliminary report.

This year marks the launching of WeBWorK's national dissemination project; assessment is a critical aspect of the five-year plan. This session will review very briefly the first wave of our assessment focused on informal student surveys and observations, and the second, a more formal examination of surveys and a keystroke-level analysis of student responses to the system. Also outlined will be our third wave, just getting underway, an assessment plan with two major components: understanding the best ways to support instructors as they adapt the system to their own courses and developing a network to support the ongoing study of WeBWorK's impact on student learning. (Received September 21, 2009)

1056-M1-1170 **Laura A. McSweeney*** (lmcsweeney@fairfield.edu), Math and Computer Science Dept, BNW 111, Fairfield University, 1073 N. Benson Rd., Fairfield, CT 06824. *What I Learned about Using Online Homeworks from Student Feedback.*

Instructors have many reasons why they choose to use an online homework system in their mathematics courses. However, it is important to know what effect these systems have on student learning. There are mixed messages in the literature regarding the effectiveness of the online homework systems on student learning. Some published studies that examine the effectiveness of online systems conclude that online homework systems show no improvement compared to traditional homework while other studies show that online homeworks do improve student learning. In this presentation, I discuss how one can use student feedback as a form of assessment of the impact of online homework systems on their learning. (Received September 21, 2009)

1056-M1-1542 **Daniel L McGee*** (mcgeedan@gmail.com), Department of Mathematics, P.O. Box 9018, University of Puerto Rico, Mayaguez, PR 00681-9018, and **J Maider Marin** (mayejudi@gmail.com), P.O. Box 9018, Mayaguez, PR 00681-9018. *Using Public Domain Software for Online Homework and Tutorials at the University of Puerto Rico.*

The University of Puerto Rico in Mayaguez(UPRM)recognized that failure and withdrawal rates in basic mathematics courses are the most significant reason that less than 50% of science and engineering students eventually graduate at the UPRM. Correspondingly, with the help of the department of education, it launched an initiative to improve student performance in precalculus and calculus courses. The initiative involved internet quizzes and tutorials that are administered with public domain web based software developed at the UPRM. Our final effectiveness study compared two groups that were fundamentally equal in all respects except use of the UPRM tools. The results were as follows. A B C D F W Calculus Students with UPRM Tools 11.65% 12.62% 27.18% 8.25% 19.42% 20.87% Calculus Students w/out UPRM tools 5.84% 4.38% 21.90% 9.49% 32.12% 26.28%

As can be seen from these results, the UPRM tools have been very successful. This presentation will show how the public domain UPRM tools were implemented, will present more thorough results and will invite other institutions to form a cooperative so that online homework and tutorials may be implemented using public domain programs with quiz questions and tutorials shared between institutions that create them. (Received September 22, 2009)

1056-M1-1571 **A. S. Elkhader*** (elkhadea@northern.edu), Department of Mathematics, Northern State University, 1200 S. Jay St., Aberdeen, SD 57401. *Online Assessment of Homework in College Algebra and Math Concepts For Teachers Courses.*

The purpose of this work is to provide a variety of assessment tools used in assessing students performance in two online courses. Homework assessment tools such as WebAssign was used in college algebra, while MyMathLab was used in the math concepts for elementary school teachers courses. Furthermore, writing components and regular communications are used as assessment tools as well. (Received September 22, 2009)

1056-M1-1611 **Tina Alves Mancuso*** (mancut@sage.edu), Department of Mathematics, 140 New Scotland Avenue, Albany, NY 12208. *Increasing Student Success Using Online Homework.* Preliminary report.

This paper, addressing assessment and evaluation, will describe the author's experiences and results from implementing an online homework system in a variety of introductory general education mathematics courses. This study was motivated by an experience the previous year at a different institution using a text that came with an online homework system, and noting higher course grades. To remove the confounding factor of the different institution, grades in this fall's courses will be compared with those of previous semesters. Packages to be discussed include WebAssign, MathZone, and Course Compass. (Received September 22, 2009)

1056-M1-1706 **Thomas R Hagedorn*** (hagedorn@tcnj.edu), Department of Mathematics and Statistics, The College of New Jersey, P.O. Box 7718, Ewing, NJ 08628, and **Karen Clark** (kclark@tcnj.edu), Dept. of Mathematics and Statistics, The College of New Jersey, P.O. Box 7718, Ewing, NJ 08628. *Using WeBWorK in Linear Algebra.*

We will discuss the use of WeBWorK in Linear Algebra courses using problem libraries developed by faculty at the University of Rochester, TCNJ, and other institutions. We will also discuss the current progress adapting ATLAST type problems and computer laboratory problems as WeBWorK problems and our experiences using them. (Received September 22, 2009)

1056-M1-1841 **Semail ULGEN YILDIRIM*** (sulgen@math.northwestern.edu), 2033 Sheridan Rd, Lunt Hall 223, Evanston, IL 60208. *Common Innovative Uses of Online Homework Systems Webassign, MyMathLab, and WebWork.* Preliminary report.

Teaching online classes and face-to-face classes with online homework assignments for several years at different institutions, I experienced the benefits of using (different) online homework systems. I also observed that students benefiting from it in many ways. I used Webassign, MyMathLab. I never used WebWork in my classes, however I was given information about it directly from the creator of it during my short visit to the University of Rochester which I appreciated. I am in the process of learning more about WebWork with greater expectations such as it is superior to the other commercial ones, however there is still time to make that conclusion. I plan on presenting my comparison to the audience by declaring some innovative uses of online homework systems Webassign, MyMathLab, and WebWork which hopefully will increase the amount of interaction in the classroom. (Received September 22, 2009)

1056-M1-1843 **Gerald Agbegha*** (gagbegha@jcsu.edu), 100 Beatties Ford Road, Johnson C. Smith University, Dept. of Narural Science and Mathematics, Charlotte, NC 28216, and **Nailong Guo**. *Using Multiple Technologies to Engage Students in Math Learning.* Preliminary report.

No one technology is perfect and/or enough for every aspect of math teaching and learning. Therefore, we need to use multiple technologies to better engage students. We use CourseCompass for homework assignments, Moodle for quizzes and tests, TI calculator for solving problems graphically and numerically, Excel for projects, multimedia projector and Tablet PC for lecture presentation, and Maple for the projects of upper level courses, such as Multivariable Calculus, Differential Equations, etc. We will present how to combine traditional teaching means with technologies, how to choose and apply different technologies, and how to use some tricks and tips for using them in math teaching and learning.

Key words: Technologies, Mathematics, Student Engagement. (Received September 22, 2009)

1056-M1-1862 **Stephanie A. Swainston*** (Stephanie.A.Swainston@aggiemail.usu.edu), Department of Mathematics and Statistics, 3900 Old Main Hill, Logan, UT 84322, and **Brynja R. Kohler** (Brynja.Kohler@usu.edu), Department of Mathematics and Statistics, 3900 Old Main Hill, Logan, UT 84322. *The Utilization of Discussion Boards for Homework in an Interactive Delivery Course: Linear Algebra and Differential Equations.*

The Utah Mathematics Endorsement Project (UMEP) offers a variety of undergraduate mathematics courses for professional teachers to raise their teaching qualifications. Classes are delivered through an interactive broadcast satellite system. As part of the project, we taught Applications of Linear Algebra and Differential Equations this summer. We decided on several different methods of assessing students' understanding. We assigned homework problems, and created corresponding discussion topics online through Blackboard Vista. Participation in the discussion boards replaced turning in traditional assignments. In this article, we will discuss our structure and rationale behind the homework. We will also share our analysis of students' use of the discussions, how they felt about using them, and their effectiveness as a learning tool. Overall, we have evidence that the discussions benefited students' understanding of concepts taught in class, and that students gained appreciation for discussing mathematics. We will explain our strategies for getting through a large number of posts, and give suggestions for anyone who wishes to use discussion boards. Lastly, we will make recommendations based on our experiences for changes to try in future classes. (Received September 22, 2009)

1056-M1-2029 **Ann E Moskol*** (amoskol@ric.edu), Rhode Island College, Providence, RI 02908.
*Implementing Online Homework and Quizzes in a Pre-Calculus Course: Challenges and Rewards.* Preliminary report.

During the 2009 fall semester, I decided to use WebAssign for online homework and quizzes in two sections of Pre-Calculus. So far, students appear to like having more than one chance to answer a problem, and the help that WebAssign provides. The communications tools allow me to provide timely feedback on specific problems. The introduction of WebAssign has had some unexpected challenges. Some of my students find this system frustrating, and have handed in written answers. During peak evening hours when many students are on the system, students find the system slow and are unable to submit their work. It will be interesting to see if this problem is resolved. In addition, students have complained that some solutions are incorrectly graded. In this talk, I will reflect on the challenges and rewards in implementing this online homework system. I will provide specific examples of algebraic solutions which were not interpreted appropriately. In addition, I will report and summarize how my students evaluated this online tool. (Received September 22, 2009)

1056-M1-2044 **Michael B Scott*** (mscott@csumb.edu), Mathematics & Statistics Department, California State University, Monterey Bay, 100 Campus Center, Seaside, CA 93955. *Using Online Homework and Data Mining to Assess Student Learning in Mathematics Courses.* Preliminary report.

CSU Monterey Bay uses a web-based homework system to supplement Pre-Calculus, Calculus, and Mathematics for Elementary School Teachers courses. The infrastructure of the homework system has expanded into a course management system used to coordinate every aspect of the course. Expansion of the system makes possible the collection of rich data streams about individual students. Mining this data enables longitudinal studies of student learning. The presenter will discuss strategies for incorporating online homework into mathematics courses, and will also share his work exploring mathematical performance patterns as students progress from lower-division courses into upper-division courses. (Received September 22, 2009)

1056-M1-2071 **Ronnie P Crane*** (craner002@hawaii.rr.com), 1108 Mokapu Boulevard, Kailua, HI 96734. *Online Homework - Does It Work ?* Preliminary report.

For several years, I have given each student a choice of either doing their homework online or hand-writing it and checking their work with the solutions I distribute. Is there a distinct difference in their performance and learning using one method or the other? What are the strengths and weaknesses of each method? I will attempt to answer these questions based on the data I have collected from my pre-calculus and calculus classes. (Received September 23, 2009)

# *Philosophy of Mathematics for Working Mathematicians*

1056-M5-259 **James R Henderson*** (henderso@pitt.edu), 504 E. Main Street, Titusville, PA 16354.
*What Is the Character of Mathematical Law?*

The proposition that mathematics may be treated as just another empirical science has its origin in the writings of John Stuart Mill and is still defended by some philosophers of mathematics to this day: Lakatos argues that, like those of the physical sciences, mathematical investigations are quasi-empirical in nature; Maddy has said that sometimes axiom adoption in set theory "has more in common with the natural scientist's hypothesis formation than the caricature of the mathematician writing down a few obvious truths;" Goodman has gone as far as to say that "mathematics is no more different from physics than physics is from biology." If one assumes Mill's position, which I will call "naturalized mathematics," it seems not unreasonable to use the extant literature on laws of nature as a starting point for an investigation into the nature of the laws of mathematics, though, of course, this is not the originally intended application. Versions of laws of the physical sciences include the regularity, necessitarian, universals, systems, anti-realist, and anti-reductionist accounts. This presentation will assume the naturalized-mathematical position and consider which account best fits the laws of mathematics. (Received August 21, 2009)

1056-M5-444 **Daniel C. Sloughter*** (dan.sloughter@furman.edu), Department of Mathematics, Furman University, Greenville, SC 29613. *Being a Realist Without Being a Platonist.* Preliminary report.

We consider something to be real if it's properties do not depend on what any collection of people might think of it. Many mathematicians tend to think this way about mathematical objects: as G. H. Hardy puts it, "317 is a prime, not because we think so, or because our minds are shaped in one way rather than another, but because it is so, because mathematical reality is built that way." To explain their realism, Hardy and others often rely on the language of Platonism. As Alain Connes says, the object of mathematics is "not material, and it is located in neither space nor time," but nevertheless "has an existence that is every bit as solid as external reality, and mathematicians bump up against it in somewhat the same way as one bumps into a material object in external reality." Yet Platonism brings with it significant philosophical baggage, to the point that the world of ideas becomes in some way more real than the world of individuals, and knowledge involves peeking into a world of which we have no physical contact. But to be a realist does not necessitate being a Platonist. We can hold both "dogs" and "dog" to be real without a dog becoming a mere shadow. This talk will draw upon the thought of C. S. Peirce to formulate how one may be a realist without being a Platonist. (Received September 07, 2009)

1056-M5-445 **Lawrence A. D'Antonio*** (ldant@ramapo.edu), 505 Ramapo Valley Rd, Mahwah, NJ 07430. *Molyneux's Problem.* Preliminary report.

On July 7, 1688, the Irish natural philosopher William Molyneux wrote a letter to John Locke posing the following question. Suppose a person, being blind from birth, having learned to distinguish between a sphere and a cube of equal size by touch, where to suddenly acquire sight; would that person then be able to distinguish the sphere and cube by sight alone? This problem, having philosophical, psychological and mathematical aspects, has been a source of interest and dispute up to the present day. Besides Locke, thinkers such as Berkeley, Leibniz, Voltaire, Diderot, and Helmholtz have discussed the problem (with no consensus as to what the correct answer should be). This talk will discuss the history of this problem and address the issue of the conceptual basis of our perceptions of geometric form. (Received September 07, 2009)

1056-M5-596 **Carl E. Behrens*** (cbehrens@crs.loc.gov), 5107 Cedar Rd., Alexandria, VA 22309. *John Stuart Mill's "Pebble Arithmetic" and the Nature of Mathematical Objects.*

The empiricist claim that all human knowledge rests on observation of physical events has always stumbled over phenomenon of abstract thought. David Hume tried to avoid the problem by defining two types of knowledge, which he called "matters of fact" and "relations of ideas," which latter he accepted as true in themselves. John Stuart Mill, however, insisted that even statements of abstract thought, including mathematical laws, were assumed to be true in general because they were observed to be true in single instances. To make this claim plausible Mill declared that "all numbers are numbers of something." This "pebble arithmetic," as his critics termed it, led to the disparagement of empiricism in the 20th Century, but it is no longer necessary to tie abstract mathematical objects to the external world. Whatever else they are, mathematical thoughts, along with all other thoughts, may be viewed as physical states of the brains of human beings, and thus as physical objects that may be observed as sources of empirical knowledge. (Received September 14, 2009)

1056-M5-1015 **Jeff Buechner*** (buechner@rci.rutgers.edu). *Mathematical practice and the philosophy of mathematics.* Preliminary report.

If the philosophy of mathematics had never existed, would contemporary mathematical practice be different from what it now is? I'll argue that it would be quite different in several respects, some of which are hardly controversial, having to do with (i) the developments in set theory that were a reaction to the discovery of the set-theoretic paradoxes and (ii) with the intuitionistic critique of classical mathematics. There are also respects in which it would not be different, and these respects are important, since they underscore a point that philosophers of mathematics need to explain: there are properties, structures and objects in mathematics that are immune to philosophical questioning of the foundations of mathematics. The question is why this is so. I'll attempt an explanation that develops an analogy between natural kind terms in the empirical sciences and mathematical inscriptions, although the analogy breaks down at a certain point, which (I claim) characterizes the difference between the empirical sciences and mathematics. (Received September 19, 2009)

1056-M5-1635 **Thomas Drucker*** (druckert@uww.edu), Department of Mathematical and Computer Sci., University of Wisconsin–Whitewater, Whitewater, WI 53190. *Dummett Down: Intuitionism and Mathematical Existence.* Preliminary report.

Michael Dummett's views on global anti-realism were shaped by his technical work on intuitionism. In particular, his criteria for existence are based on an intuitionistic view of truth. From this has sprung a whole array of anti-realisms that are discipline-specific. Whether that anti-realism fits the issue of the existence of mathematical objects particularly well is not resolved by this account of its origins. There was, after all, intuitionism before the formalization created by Heyting and pursued by many others. Here the history of intuitionism will be used to separate the Dummettian programme in general from the contribution intuitionism can make to understanding statements about mathematical objects. (Received September 22, 2009)

1056-M5-1771 **Martin E Flashman*** (flashman@humboldt.edu), Department of Mathematics, Humboldt State University, Arcata, CA 95521. *The Articulation of Mathematics-A Pragmatic/Constructive Approach to The Philosophy of Mathematics.* Preliminary report.

The philosophy of mathematics has often taken mathematics as a realm of discourse that is fixed. The investigation of this realm is what working mathematicians take as their task. This work leads to results and reports on what they have ascertained. Accompanying communications allow others to achieve comparable experiences of understanding or to accept the results for further investigations. The author will discuss an alternative "constructive" view: The mathematical realm is dynamic and changing while the work of mathematicians involves the articulation of this realm as a pragmatic work in progress. (Received September 22, 2009)

1056-M5-1918 **Ruggero Ferro*** (ruggero.ferro@univr.it), via gabelli 57, 35121 padova, Italy. *An analysis of the notion of natural numer.*

I would like to address the theme of this meeting selecting the notion of natural number. I will try to point out the human problems and needs that motivate the elaboration of the notion of natural numbers, and to illustrate the steps and the choices made to arrive to a solution of the problems. The main problem is to compare quantities of elements. A procedure that could solve the problem in some difficult cases is that of counting. By counting we associate to each finite collection an ordered collection of iterations of the mental acts of considering a further element. These ordered collections could be viewed as the natural numbers. At this point we have two possible line of development. One, we can examine the structure of the collection of the entities that were introduced and the problem of infinity that it is raised. Two, one can consider the steps taken along the way of constructing the proposed notion of natural number, and analyze what it is needed to perform them. Most of the steps require introspections. This is due to the fact that we have to use internal perceptions. This notion of natural numbers somehow answers the question about their nature; and their existence is similar to the existence of plans, projects, organization, and mental activity. (Received September 22, 2009)

# *Preparing K–12 Teachers to Teach Algebra*

1056-N1-36 **Ira J Papick*** (ipapick2@math.unl.edu), Mathematics Department, 203 Avery Hall, University of Nebraska-Lincoln, Lincoln, NE 68588, and **Jim Lewis** (wlewis1@math.unl.edu), Mathematics Department, 203 Avery Hall, University of Nebraska-Lincoln, Lincoln, NE 68588. *Algebra for Algebra Teachers.* Preliminary report.

Algebra for Algebra Teachers is part of a 3-course, 9 credit hour graduate integrated sequence that assists practicing Algebra teachers in becoming master Algebra teachers with special strengths in algebraic thinking and knowledge for teaching algebra to middle/high school students. The main goal of the course is to help teachers better understand the conceptual underpinnings of school algebra, and how to leverage that understanding into improved classroom practice. Emphasis will be placed on developing the habits of mind of a mathematical thinker.

During a 2-week summer institute, teacher participants take 2 integrated 3 credit hour graduate courses: Algebra for Algebra Teachers and Seminar in Educational Psychology: Cognition, Motivation, and Instruction for Algebra Teachers. In the academic year following their participation in the summer institute, teachers will return to the classroom and work with an instructional coach or teaching mentor as they strive to transfer knowledge gained in the summer institute into improved classroom practice. To complete the sequence, participants take a 3 credit hour yearlong pedagogy practicum course focused on enhancing their ability to teach algebra to all students and to becoming a reflective practitioner. (Received July 07, 2009)

1056-N1-242 **Kien H. Lim*** (kienlim@utep.edu), Department of Mathematical Sciences, 500 W. University Ave, University of Texas at El Paso, El Paso, TX 79968-0512. *Bridging Proportional Reasoning and Algebraic Reasoning: A Focus on Co-variation and Invariance Using Contextualized Problems.*

Proportion and algebra are typically connected via linear functions, by helping students relate $a/b = c/x$ to $y = mx$ which is subsequently extended to $y = mx + b$. A way to deepen pre- and in-service teachers' understanding is to draw their attention to the structure underlying a contextualized-problem situation, by focusing on co-variation and invariance. Consider the following missing-value problem: Alex and Bob were running at the same speed around a track. Alex started first. When Alex had run 10 laps, Bob had run 6 laps. When Bob completed 15 laps, how many laps had Alex completed? 31% of 81 pre-service K-4 teachers over-generalized proportionality and chose 25 laps (40% chose 11 laps). Such a problem can help pre-service teachers recognize their disposition to apply proportional strategies to solve missing-value problems without attending to quantities and relationships.

A follow-up question such as "write an equation to relate the number of laps Bob had completed, b, to laps Alex had completed, a," can help pre-service teachers recognize that the difference a - b is invariant while a and b co-vary. For proportional situations, the ratio a/b is invariant. For inverse-proportional situations, the product ab is invariant. For other situations, the sum a + b could be invariant. (Received September 08, 2009)

1056-N1-265 **Murray H Siegel*** (murray.siegel@asu.edu), 20159 N Geyser Dr, Maricopa, AZ 85138. *Place Value – the Link Between Arithmetic and Success in Algebra.*

Learning theory indicates that accommodation of new learning is aided by linking new knowledge to concepts that have already been learned. Teachers at all grade levels must see polynomials as a generalization of whole numbers and that the powers of the variable are place values. Operations with polynomials and polynomial fractions are easily understood if tied to arithmetic. Preparing students to teach mathematics at any level in k-12 must include a study of place value both with whole numbers and polynomials. This presentation describes lessons that have been used successfully in both pre-service and in-service classes to accomplish that goal. These lessons include a study of arithmetic using alternate bases and checking polynomial problems using x = 10. (Received August 22, 2009)

1056-N1-383 **Steve Blair*** (sblair6@emich.edu), Eastern Michigan University, Department of Mathematics, 515 Pray Harrold, Ypsilanti, MI 48197. *Using modified materials from The Algebra Project with pre-service K-8 mathematics teachers.* Preliminary report.

We will present a preliminary report regarding the use of a modified version of the Road Coloring unit (originally developed by Greg Budzban for The Algebra Project) with preservice K-8 teachers at Eastern Michigan University. The Road Coloring unit facilitates students' development of multiple representations of the function concept as they "mathematize" their experience solving problems that involve the creation and coloring of directed graphs. The goals of using a modified version of the Algebra Project curriculum (designed for a high school Algebra I course) with the preservice K-8 teachers was two-fold: to deepen their own understanding of the subject matter (functions), and to provide an experience from which they could discuss pedagogical issues concerning teaching algebra concepts to kids. (Received September 03, 2009)

1056-N1-478 **Steve Benson*** (sbenson@lesley.edu), Division of Natural Science and Mathematics, Lesley University, 29 Everett Street, Cambridge, MA 02138-2790. *Calculus: A Gateway to Algebra?!* Preliminary report.

We all know the old adage, "you don't really learn anything until you have to teach it," which has *some* truth to it, since it's through carefully working with and thinking about a particular topic that one builds a deep understanding. Of course, a better adage would be, "you don't learn something until you have to use it," which I propose to further "morph" to "it's hard to teach something if you don't really see where it leads."

I will discuss our calculus course for in-service elementary and middle school teachers, sharing quotes from teachers about how participating in the calculus class(es) changed their approach to teaching pre-algebra and algebra courses in elementary and middle school. The success of this course in helping teachers see the relevance of - and improve their confidence and practice with - proportional reasoning, algebraic thinking, and problem solving has led us to reconsider our sequence of courses for preservice teachers. (Received September 09, 2009)

1056-N1-481 **Carol E Seaman*** (ceseaman@uncg.edu), 7402 Fairhaven Dr., Greensboro, NC 27455, and **Jennifer Earles Szydlik**. *Big Ideas in Algebra: Materials to Foster Mathematical Thinking.*

Based on our constructivist philosophy of learning and our ongoing work with preservice and practicing teachers, we have developed NCTM Standards-based curriculum materials for preservice teachers. Our algebra text focuses on algebra as the study of arithmetic structures, patterns and functions, and building and solving equations. Each topic begins with a motivating Class Activity designed to introduce a big idea through small-group work in class. A Read and Study section that provides normative definitions and notation, a Connections to the Middle Grades section focused on children's thinking about the topic and samples of relevant middle grades curricula, and Homework presented within the context of the activity ideas follow.

Beyond understanding the fundamental concepts of algebra, we want our students to reason like mathematicians. We aim to show students that algebra is not a subject to be memorized; it is about ways of exploring, thinking and knowing. In this session we will share our best algebra activities and we will describe the class conversations that arise from work on them. In particular, we will focus on how we develop aspects of mathematical reasoning such as a profound appreciation for definitions, notation, and counterexamples, and the ability to generalize. (Received September 09, 2009)

1056-N1-803 **David Fowler*** (dfowler@unl.edu), 16 Henzlik Hall, University of Nebraska, Lincoln, NE 68588-0355. *Inquiry as an Outcome of Algebra.* Preliminary report.

College mathematics students planning to become secondary mathematics teachers need to be prepared for conceptual explanations, especially explanations that novice learners can comprehend. In this presentation, I will show a number of examples of "inquiry patterns" based on algebraic concepts. These examples are used in a teacher preparation course, and are based on both college-level mathematics and high school mathematics from an advanced perspective. These patterns can then be applied to basic explanations at the level of beginning learners.

This presentation includes a synthesis of ideas including a basic definition of "inquiry" (Dewey), patterns of inference (Polya), cognitive transfer (Perkins and Salomon) and applications of the philosophy of mathematics in the mathematics classroom (Flashman, MAA Minicourse 2008). (Received September 17, 2009)

1056-N1-865 **Dianna Spence*** (djspence@ngcsu.edu), NGCSU Dep't. of Math & Computer Science, 82 College Circle, Dahlonega, GA 30597, and **A. Robb Sinn**. *Visualizing Algebraic Relationships: Solving Combined Rate Problems with Pattern Blocks.* Preliminary report.

Consider the question: "Mary fills 3 balloons per minute. Joe fills 5 balloons every two minutes. Working together at these rates, how long will it take them to fill 440 balloons to decorate for the prom?" We share a technique of visualizing and solving problems of this type using pattern blocks. This technique has been introduced in a mathematics content course for K-8 pre-service and in-service teachers. The course, 'Modeling in Algebra', is required for our undergraduate degree programs that result in K-8 teacher certification. A graduate-level version of the course is available for in-service teachers working on masters degrees. We discuss connections students make about problem solving, rates, fractions, and algebraic relationships while using manipulatives, and we share the results of a pilot test that compared this instruction technique to more traditional "procedural" instruction on combined rate problems with K-8 pre-service and in-service teachers. Included is a discussion of successes and challenges experienced. (Received September 18, 2009)

1056-N1-954 **Joshua D Chesler*** (jchesler@csulb.edu), Department of Mathematics and Statistics, 1250 Bellflower Blvd., California State University, Long Beach, Long Beach, CA 90840-1001. *Teachers, Mathematicians, and Educators Making Sense of Algebra Content.*

A teacher's interactions with algebra content are shaped by varied and complex factors such as her/his knowledge and beliefs as well as by the particular representation of the algebra content. The settings for this study were two workshops in which algebra teachers, mathematicians, and mathematics educators were separately tasked with discussing and categorizing middle/high school algebra problems. The study's goals included an examination of the knowledge and beliefs which influenced these interactions with algebra. I will report on some outcomes which may provide insight into the ways in which teachers make sense of algebra curricular materials. For example, teachers (as compared to members of the two other professional groups) analyzed the problem set with frequent reference to and guidance by their perceptions of students. I will discuss some potential implications of these outcomes for developers of curricular materials and for instructors of pre-service and in-service teachers (Received September 18, 2009)

1056-N1-1338 **Ji Li*** (jli@math.arizona.edu), Department of Mathematics, The University of Arizona, 617 N. Santa Rita Ave., Tucson, AZ 85721-0089. *An algebra course for middle school teachers.*

The Arizona Teacher Initiative (ATI) master's degree program in middle school mathematics leadership targets middle school teachers with elementary certification. They are trained with mathematics content, engaged in pedagogical discussion, and design an action research project. Algebra is one of the four core course in the program. This 4-unit course combines mathematics content with pedagogical discussion throughout. The two threads are intertwined during teaching. The current ATI algebra is made possible under the group effort of William McCallum, Bruce MacMillan, Alyssa Keri, Virginia Bohme, and Ji Li. In this talk we will give an overview of ATI algebra, as well as present some examples to illustrate the design of this content. (Received September 22, 2009)

1056-N1-1475 **Leah Bridgers*** (BridgeLC@oneonta.edu), Dept. of Math, CS and Stat, Fitzelle Hall, SUNY Oneonta, Oneonta, NY 13820. *Dihedral Groups for Preservice Elementary Teachers.*

Many preservice elementary teachers complete mathematics content courses as part of their undergraduate program. In this talk, we will discuss an activity used in a mathematics content course for preservice elementary teachers that serves several purposes: (1) It introduces students to dihedral groups; (2) It helps to reinforce students' understanding of closure, identity, inverses, associativity and noncommutativity; and (3) It helps students to make connections between geometric ways of thinking and algebraic properties of many of the number systems with which they are familiar. (Received September 21, 2009)

1056-N1-1477 **Michael Mays*** (Michael.Mays@mail.wvu.edu), Math Department WVU, Morgantown, WV 26506-6310, and **David Miller** (millerd@math.wvu.edu), Math Department WVU, Morgantown, WV 26506-6310. *On Line Number and Algebra for In-Service Middle School Math Teachers.*

The on line courses are offered as a two credit hour mathematics course and a one credit hour corequisite Curriculum and Instruction course, part I of both Math and C&I typically taught in the fall semester and part II in the spring semester.

The overall objectives of the courses are to increase knowledge and competence for middle school mathematics teachers in both content and pedagogy related to the teaching and learning of number and algebra.

The "pedagogy" portion, addresses objectives of classroom relevance:

- Relate the advanced mathematical topics above to topics taught in the middle school classroom.
- Examine current research in teaching and learning mathematics.
- Explore model middle school mathematics curricula such as Connected Mathematics.

In addition, applications demonstrate the utility of the mathematics. Technology including graphing calculators, Java applets and other Web resources are used to ground number and algebra concepts and to model and solve real world problems. The applets are also available for download, and are available on line to be incorporated into other courses. (Received September 21, 2009)

1056-N1-1643 **Agnes M Rash*** (arash@sju.edu), Dr. Agnes M. Rash, Mathematics Department, Saint Joseph's Univeristy, Philadelphia, PA 19131. *An Innovative Course in Elementary Number Theory for Preservice Teachers.* Preliminary report.

The new requirements for elementary school teacher certification in the Commonwealth of Pennsylvania have very specific recommendations for the content of the mathematics courses for elementary school teachers. Among these is a recommendation for a course for preservice teachers of middle school (grades four through eight) that includes knowledge of the basic concepts of number theory. The Whole Truth about Whole Numbers is a newly developed course to serve the needs of future elementary school teachers. A preliminary version of the course is being offered in Fall 2009 and will be evaluated with respect to meeting the goals set forth for the knowledge and attitudes of elementary school teachers.

Students will become familiar with elementary theoretical concepts in mathematics. In addition, students will enhance their problem-solving skills, elementary algebra skills and their writing of mathematics solutions and proofs. This talk will discuss the topics included in the course, the learning objectives, the delivery of the course content, and course outcomes including assessment of student learning and attitudes. (Received September 22, 2009)

1056-N1-1699 **Diana White*** (diana.white@ucdenver.edu), University of Colorado Denver, Campus Box 170, P.O. Box 173364, Denver, CO 80217-3364. *A course in Mathematical Knowledge for Teaching for pre-service secondary teachers.*

To effectively teach algebra, teachers must be proficient with the algebraic thinking that arises naturally in the material that students learn before algebra. In this talk, we discuss an innovative course in Mathematical Knowledge for Teaching for pre-service secondary math teachers. The course was co-taught by a mathematician and a high-school teacher, and course topics focused on number and operation as well as geometry at the middle level. Algebraic thinking was a recurrent theme, and connections to algebra were continually emphasized. We discuss course design and implementation, and both quantitative and qualitative data that was collected in a pre-post format. (Received September 22, 2009)

1056-N1-1786 **Susan L. Addington*** (saddingt@csusb.edu), Math Dept., CSUSB, 5500 University Pkwy., San Bernardino, CA 92407. *Measuring the World: Preparing Elementary Teachers to Prepare Students for Algebra.*

Measuring the World is a complete textbook for a math for elementary teachers course. It is available in preliminary form online. MtW takes the point of view that arithmetic and algebra are a syntax for modeling measurement, as well as counting. The book grounds students in measurement activities and links the activities to the symbolic mathematics they have previously learned in school. Pretests show huge gaps in these students' mastery of measurement. Much research in the last few decades has shown that "multiplicative thinking" is the main bottleneck for algebra; this includes not only multiplication and division, but also fractions, proportions, linear functions, exponents and logarithms, as well as basic aspects of measurement such as units and area. Preparation for algebra in MtW happens in three stages: (1) Concepts of measurement, number, and operations. This includes discussions of properties of number systems in contextual situations, as well as reading and writing expressions. (2) Multiplicative thinking, modeling proportional relationships with tables, parallel number lines and graphs, and function arrow diagrams, before moving to the traditional algebraic methods for solving proportions. (3) Elementary functions, in context, with tables and graphs. (Received September 22, 2009)

1056-N1-1800 **Susanna Epp*** (susanna.s.epp@gmail.com), Department of Mathematical Sciences, DePaul University, 2320 N. Kenmore, Chicago, IL 60614. *The Concept of Variable and the Logic of Solving Equations and Inequalities.*

This talk will report on experiences working with prospective and practicing high school and middle school teachers over many years. The focus will be on discussion of materials to help current and future teachers deepen their understanding of the concept of variable and of the logical reasoning that underlies the solution of equations and inequalities. (Received September 22, 2009)

1056-N1-1804 **Rebecca H McGraw*** (rmcgraw@math.arizona.edu), 617 N Santa Rita Ave, Tucson, AZ 85721, and **William McCallum**. *Connecting Mathematics and Pedagogy in Courses for Future Algebra Teachers.*

Integrating mathematics content and pedagogy in mathematics teacher preparation requires the combined attention of faculty who teach future teachers, namely, mathematicians and mathematics teacher educators. Collaborations across these disciplinary boundaries have resulted in various strategies useful to the preparation of future algebra teachers. Specific methods developed through one such collaboration at the University of Arizona include (1) development of particular mathematical content, e.g., definition of function, followed by analysis of the ways such content is introduced in algebra textbooks, (2) mathematical investigations of exploratory problems at the undergraduate level coupled with the development of problems and lessons to be used with algebra students, and (3) using exemplary lessons for algebra students as a basis for building and extending mathematical knowledge, and then using that knowledge to write questions, assessments, and extensions for algebra students. Each of these examples is characterized by the co-development of mathematical and pedagogical knowledge, and the lessening of traditional separations between these knowledge domains. (Received September 22, 2009)

1056-N1-1927 **Dale R Oliver***, Humboldt State University, Department of Mathematics, Arcata, CA 95521. *Guiding Teachers to See Opportunities for Algebraic Reasoning in the Curriculum.* Preliminary report.

In far North-West California, 30 teachers of grades 3 – 8 are participating in a professional development program designed to positively affect student learning by enhancing the teachers' knowledge of mathematics. One of the target mathematical areas of the project is algebra, with a goal of helping teachers develop a coherent view of the subject and its foundations throughout the elementary and middle school math curriculum. In addition to studying mathematics and pedagogy in a workshop setting, teachers in the program create and implement a brief curriculum project in which they engage their students in algebraic reasoning and measure the effect of that engagement. It is in through these projects, the subsequent collaboration with colleagues, and the written reflections on the projects that we see evidence of growth in teacher understanding of algebra and algebraic reasoning. This preliminary report will include an outline of the professional development model that is being used, as well as sample teacher projects and a brief analysis of results to date. (Received September 22, 2009)

1056-N1-2057 **Trisha A. Bergthold*** (bergthold@math.sjsu.edu), Department of Mathematics, San Jose State University, One Washington Square, San Jose, CA 95129-0103. *Extending from Multiplication of Two-Digit Numbers to Multiplication of Binomials and Beyond: Understanding the Learning Trajectory.* Preliminary report.

This presentation will describe a learning trajectory focused on multiplication of binomials. The learning trajectory was presented to teachers (grades 7-9) in a professional development program aimed at algebra readiness. The trajectory illustrates three main points. First, a conceptual understanding of multiplication of two-digit numbers can be built in earlier grades through the use of manipulatives, rectangular models, and scaffolding from partial products charts to the partial product algorithm to the standard algorithm for multiplication. Second, a comparable trajectory can be utilized to build a conceptual understanding of multiplication of binomials. Third, this conceptual understanding of multiplication of binomials forms the basis for building an understanding of how to "unmultiply" trinomials. The genesis for this idea came from the recognition that many teachers have not had opportunities to examine mathematical concepts vertically, that is, across multiple grade levels. By looking at a vertical slice of content, teachers learn how to capitalize on what students already know, remediate what they don't know, and emphasize the pieces most crucial to understanding what lies ahead for them. (Received September 23, 2009)

1056-N1-2058 **Tina Louise Johnston*** (johnstot@onid.orst.edu), Department of Science and Math Educaiton, Weniger 239, Corvallis, OR 97331-6508, **Henry Gillow-Wiles** (gillowwh@onid.orst.edu), Department of Science and Math Educaiton, Weniger 239, Corvallis, OR 97331-6508, and **Margaret L. Niess** (niessm@onid.orst.edu), Department of Science and Math Educaiton, Weniger 239, Corvallis, OR 97331-6508. *Helping teachers develop algebraic reasoning skills through investigation of algebraic proofs and mathematical discourse experiences.*

When the National Council of Teachers of Mathematics (NCTM) included reasoning and proof in K-12 mathematics standards (NCTM, 2000), elementary teachers were placed in a key role in mathematics reform. However, many elementary teachers have little training or experience with aspects of mathematical reasoning that must become the norm in classroom instruction (Blanton & Kaput, 2005). Using a combination of written and video-recorded qualitative data with performance based quantitative data analysis, the effect of a 10-day intensive summer institute focusing on developing algebraic reasoning and concept skills in 12 in-service K-8 teachers was analyzed. Results indicate that the in-service teachers perceptions about algebraic reasoning showed evidence of growth to a more complete and thorough understanding. This new understanding was further expressed by a statistically significant increase in the teachers ability to construct coherent and correct algebraic proofs from both familiar and unfamiliar conjectures (p=0.012). Documented reflections of teachers during and after participation in the program suggests that the participating in-service teachers planned to integrate both the pedagogical aspects of the course into their teaching placements as well as ideas of algebraic proof. (Received September 23, 2009)

1056-N1-2062 **Xuhui Li*** (xhli58@yahoo.com), Department of Mathematics and Statistics, California State University, Long Beach, 1250 Bellflower Blvd, Long Beach, CA 90840. *Developing a Comprehensive and Balanced Perspective on School Algebra Among Practicing Secondary School Mathematics Teachers.*

As a continuing professional development activity for secondary school mathematics teachers, MTED 540 Algebra in the School Curriculum has been offered at California State University – Long Beach to practicing teachers enrolled in the mathematics education master degree program.

The course aims at developing a comprehensive and balanced perspective on school algebra. It includes four components: 1. Analyzing the major aspects and themes of school algebra, the various conceptions on algebra, and the key features of algebraic thinking. 2. Reviewing the changing emphases and reoccurring issues in school algebra since the 1950s; Examining the major events and factors that shaped the evolution of the school algebra curriculum. 3. Evaluating and contrasting algebra-related policy documents, organizational visions and individual perspectives. In particular, three algebra standards are examined and contrasted in details: (1) NCTM 2000 Principles and Standards for School Mathematics; (2) NCTM 2006 Curriculum Focal Points; (3) Mathematics Framework for California Public Schools. 4. Based on research literature, discussing typical conceptions and difficulties that students bring into or develop during algebra learning, and potential strategies for improving student understanding. (Received September 23, 2009)

# *Publishing Mathematics on the Web*

1056-N5-341 **Claus Schubert*** (claus.schubert@cortland.edu), Dept. of Mathematics, SUNY Cortland, Cortland, NY 13045. *Displaying Mathematics with Plain HTML.*

Despite the new and powerful tools becoming available to publish mathematics on the web, there are still reasons to display mathematics with just plain HTML. Some web servers / course management systems may not allow for any of the advanced tools currently available. For example, the widely-spread course management system WebCT has an equation editor built in, but does not allow for passing variables in a calculated question to an equation built with the editor. As a result, calculated questions with objects such as matrices, integrals, and radicals have to be written in HTML. In this talk I will give a few examples of how to display such objects using just HTML with no embedded images, MathML, etc., and give a brief introduction on how to use an HTML preprocessor to write macros. A basic knowledge of HTML will be assumed. (Received August 31, 2009)

1056-N5-547 **Thomas E Leathrum*** (leathrum@jsu.edu), MCIS Dept., Jacksonville State Univ., 700 Pelham Road North, Jacksonville, AL 36265. *Math Authoring for the Web Made Easier.*

This presentation will demonstrate features of a new stylesheet which provides a hybrid of XHTML with some new elements intended to reflect LaTeX-like document structure. An embedding interface for Content Pseudo-TeX (CPT) is provided, with special tags. Most of the elements familiar from XHTML are available, as is nearly all of SVG. Additional features include: topmatter formatting, including automatic generation of the table of contents, with internal linking; LaTeX-like elements for definitions, theorems, proofs, and similar environments; automatic numbering of sections, equations, and figures; basic citation formatting, including internal reference annotations; and identifier referencing with automatic internal page linking for citations and numbers. (Received September 11, 2009)

1056-N5-630 **Matthew Leingang*** (leingang@courant.nyu.edu), Courant Institute of Mathematical Sciences, 251 Mercer St., New York, NY 10012. *A multimedia document workflow using docutils.* Preliminary report.

The LaTeX-to-HTML conversion process is error-prone and often unaesthetic when successful. We have developed a method that uses a third format, easily converted to the other two. The method can be automated and extended with makefiles to involve any kind of formatting.

Docutils consists of a markdown syntax known as *restructured text* and a set of python libraries used to convert that text into other formats. Our contribution to docutils is the added handling of LaTeXformulas with TTH, allowing math-rich documents to be processed. They then can be reliably converted into valid XHTML strict, embedded into fancier websites using XSLT, as well as typeset to PDF with LaTeX. (Received September 14, 2009)

1056-N5-712 **William F. Hammond*** (hammond@math.albany.edu), Dept. of Mathematics & Statistics, University at Albany, Albany, NY 12222. *The Importance of Good Source Markup.*

For optimal interoperability and reusability today along with durability into the future it is desirable for documents to be written in a structured author-level markup language. The didactic production system of the GELLMU project offers a fully working example. (Received September 16, 2009)

1056-N5-1050 **Robert A Beezer*** (beezer@ups.edu), Mathematics Department, University of Puget Sound, 1500 N Warner, Tacoma, WA 98416-1043. *Textbooks as Sage Notebooks.*

Sage is free, open-source mathematics software designed to become a viable alternative to Magma, Maple, Mathematica and Matlab. Besides extremely powerful routines for computing a wide spectrum of mathematical objects, Sage includes a "notebook" interface which uses standard web browsers to provide a familiar means for interacting with the program on a remote server such as sagenb.org. The principal technology used by the notebook to render mathematics is jsMath.

This talk will demonstrate a pilot project to convert textbooks authored in LaTeX to Sage worksheets as part of a Sage notebook. An author can use the vast array of packages available for LaTeX to create new content, and Sage code can be incorporated. Upon automated conversion to jsMath and the Sage worksheet format, the resulting worksheet displays high-quality mathematics and incorporates the Sage code as executable blocks, runnable and editable by the reader. Sage has excellent support for LaTeX output and the notebook includes a lightweight word processor, so a reader can annotate their work with more Sage code and similarly impressive mathematical content. (Received September 20, 2009)

1056-N5-1262 **Patrick D. F. Ion*** (ion@ams.org), Mathematical Reviews, 416 Fourth Street, Ann Arbor, MI 48103. *Tiddly Geometry.* Preliminary report.

A TiddlyWiki under development will be demonstrated which ties together text, TeX input and MathML, and diagrams using SVG, Geogebra, and Mathematica to explain some of the widely ignored, but striking, relationship between Plane Geometry and the Discrete Fourier Transform.

The changing complexion of mathematical information transfer is well illustrated by the development of the use of TiddlyWiki documents. A TiddlyWiki (http://www.tiddlywiki.org) is a single HTML file which operates in many ways like a wiki thanks to an infrastructure based on a lot of JavaScript. There have been TiddlyWikis used for collections of math problems, for theoretical physics notebooks, for publication of the Mathematical Science Classification MSC2010, and for a great number of non-scientific publishing efforts. For example, the fundamental development of TiddlyWiki has been supported recently by British Telcom, so it is of interest to business.

Generalizations of both the technology (to remotely editable TiddlyWiki, for instance) and of the mathematics (to more than two dimensions, and from polygons to polynomial zeros and interpolation, signal processing and even qubits) will be mentioned. (Received September 21, 2009)

1056-N5-1271 **Patrick D. F. Ion*** (`ion@ams.org`), Mathematical Reviews, 416 Fourth Street, Ann Arbor, MI 48103. *MathML 3.0.*

The presentation will outline the present state of MathML 3.0, the World Wide Web Consortium's Recommendation for a Mathematical Markup Language. This is not a redesign of the MathML 2 language, but the specification has been rewritten and a number of new features added. Most notable are better markup of elementary mathematics (such as long division, which is an international problem), better handling of bidirectional text, a new clarity over Content Markup, and adjustments to accord with the many new mathematical symbols in Unicode. In addition, the W3C Math Working Group has produced other specs: a MathML for CSS Profile and XML Entity Definitions for Characters.

The MathML 3.0 specification now undergoes a period of gaining experience with implementations before it can become a full W3C Recommendation. Interestingly, the spread of adoption of MathML can be seen in Microsoft Word's taking it on, and in the Windows 7 realization of handwritten math input. Already Maple and Mathematica can save in a MathML form. In addition, such efforts as MathJAX, which solves the problem of rendering of MathML by using JavaScript, are helping MathML. (Received September 21, 2009)

1056-N5-1278 **Patrick D. F. Ion*** (`ion@ams.org`), Mathematical Reviews, 416 Fourth Street, Ann Arbor, MI 48103. *Revising the MSC (Mathematics Subject Classification).*

The MSC2010 revision was done using modern tools. The talk will sketch this development for its lessons about math on the web.

Since 2007 a public website http://msc2010.org has taken suggestions about the MSC. These were tracked in a MySQL database. Editing the evolving MSC was done collaboratively and publicly by the about 50 editors of Mathematical Reviews (MR; online form: MathSciNet) and Zentralblatt (Zbl; online form: ZMATH). They used the MSCwiki on msc2010.org, an instance of a MediaWiki.

From a TeX form of the MSC come several PDF versions: linked PDFs in different formats, lists showing types of changes, and KWIC indexes of words or codes.

New is a TiddlWiki MSC which may be downloaded and annotated with mathematical formulas in LaTeX. This is done with a LaTeXMathML plugin, but can use jsMath (or the new MathJAX).

All derived documents were produced with Perl and Python scripts, which deal with the vagaries of (simple) math formulas, scholarly accents for MR and Zbl, et al.

Finally, we have a prototype of the MSC deployable like the Library of Congress subject keywords, using the new W3C rec SKOS. This is a move toward useful ontological information. (Received September 21, 2009)

1056-N5-1504 **Robert R Miner*** (`robertm@dessci.com`), 413 Wacouta Street, Suite 540, Saint Paul, MN 55101. *MathType, Math Markup, and the Goal of Cut and Paste.*

One consequence of the rise of the Web as an information source and application platform is the expectation of easy reuse. The ability to cut and paste text data between web pages and applications greatly enhances the utility of both the source and target. This presentation examines the state of the art for cut and paste of mathematical notation in Web pages.

For display, most math on the web is represented in a relatively unstructured way, e.g. as an image. By contrast, the applications that are most naturally the targets of mathematical paste operations generally require highly structured representations. However, the rise of important web applications such as blogs and wikis have made the association of equation images with more structured representations in metadata more common. Such data is most often a TeX-like language. Conversely, efforts to standardize exchange formats for mathematics, particularly MathML, have seen steadily increasing support in target applications. The combination of these factors now allows software tools, such as Design Science's MathType, to cut and paste mathematics naturally between a surprising variety of sources and targets. (Received September 22, 2009)

1056-N5-1505 **R. Alexander Milowski*** (`alex@milowski.com`), 250 Granville Way, San Francisco, CA 94127. *WebKit + MathML.*

WebKit is the core technology behind the Safari, Chrome, and mobile browsers of both the iPhone/iPod Touch and Android platforms. Recently, the presentor has taken up the cause of building native support for MathML in WebKit with the end goal of this ending up in both the desktop and mobile browsers.

This talk will detail the goals and status of the WebKit MathML project, challenges that it faces, and demonstrate some native rendering in Safari. (Received September 22, 2009)

1056-N5-1662 **Kyle T Siegrist*** (siegrist@math.uah.edu), Department of Mathematical Sciences, University of Alabama in Huntsville, Huntsville, AL 35801. *Customizing and Extending Content MathML.* Preliminary report.

This talk will describe briefly how Content MathML can be customized and extended. Moreover, I will argue that suitably modified versions of Content MathML, together with the XSL stylesheets for translation into standard Presentation MathML, can be viewed as an authoring platform. As an example I will describe the customized Content MathML and corresponding stylesheet for the project *Virtual Laboratories in Probability and Statistics.* (Received September 22, 2009)

1056-N5-1809 **Donald W. DeLand*** (don@integretechpub.com), 4015 Carlisle Blvd NE, Suite A, Albuquerque, NM 87107. *An RIA Approach to Web Mathematics.*

This talk presents the efforts of an ongoing NSF-funded project to develop a Rich Internet Application (RIA) framework for web-based mathematics. The core of the project consists of an XHTML+MathML editor implemented entirely in Actionscript and delivered using Adobe's FlashPlayer—a platform that is very lightweight, works uniformly on all major browsers and operating systems, and is already installed on practically every networked computer. Through various configurations, this editor can support collaborative web-based authoring, highly interactive instructional content, or applications that require computation.

Several key design decisions will be addressed, including the choice of Actionscript over Java as the development language, the benefits of using Content MathML in math applications, designing different interfaces for developers and end users, and the limitations that prevent an RIA approach from being a universal solution to web-based mathematics. (Received September 22, 2009)

1056-N5-1947 **Davide P Cervone*** (dpvc@union.edu), Department of Mathematics, Schenectady, NY 12308. *MathJax: a JavaScript-based engine for including TeX and MathML in HTML.*

In 2004, the jsMath JavaScript program showed that it was feasible to present TeX-based mathematics in web pages via HTML/CSS and unicode fonts in a way that works across browsers and platforms, without the need for plugins or other software installation on the part of the person viewing the web page. The results would scale properly along with the text on the page, and would print at full resolution (unlike images, the traditional way of including mathematics in web pages). Since that time, jsMath has been incorporated into dozens of wikis, blogs, course management systems, computer algebra systems, and other software as a means of presenting mathematics. Under the guidance of Design Science, Inc, and with the support of the AMS, MAA, SIAM, Mathworks, the APS, and others, the next generation of this software, called MathJax, is being developed. It is more modular, more robust, and more flexible than jsMath, and will include both TeX and MathML as input languages, bringing MathML support to a wider range of web browser than ever before. In this talk, we will present an overview of the structure of MathJax and how it works within a web page. (Received September 22, 2009)

# *Quantitative Reasoning and the Environment*

1056-P1-276 **Michael Huber*** (huber@muhlenberg.edu), Dep't of Mathematics and Computer Science, Muhlenberg College, 2400 Chew Street, Allentown, PA 18104. *Modeling Radon in Pennsylvania.* Preliminary report.

Radon is a serious issue in Lehigh County, Pennsylvania, where Muhlenberg College is located. Long-term exposure to radon can lead to lung cancer. The Environmental Protection Agency (EPA) has established guidelines and safe levels for residents in each county of the state. In my "Mathematical Modeling" elective, I have used actual data from the EPA (hundreds of data points per zip code listing) to engage students in developing models to study and predict radon levels in the Allentown area and in their own hometowns. I will discuss how I connected with state officials and local mitigation systems experts, how to access EPA data, and some of the linear regression models constructed by students. Students were required to discuss reliability of the data, confidence of the models, possible trends, and predictions for new locations. (Received August 24, 2009)

1056-P1-847 **Martin E. Walter*** (martin.walter@colorado.edu), Dept. of Mathematics, Campus Box 395, University of Colorado, Boulder, CO 80309. *Necessary Environmental Numeracy for a Successful Society.* Preliminary report.

Effective citizenship requires a basic understanding of a few concepts which are essentially mathematical. A dishonest representation of risk, a mathematically quantifiable concept, is at the heart of recent economic troubles. The statement of the "Carbon Dioxide Greenhouse Law" of Arrehnius involves nothing more complicated than logarithms, yet it is seldom mentioned. Ignoring this law makes as much sense as ignoring gravity, with similar results. Hubbert's analysis of non-renewable resources likewise is being ignored at our peril. Society's decision makers need to be held accountable by an informed population whenever they ignore(violate) these and other basic facts(laws) of Nature that are essentially mathematical. (Received September 18, 2009)

1056-P1-1093 **Michael Olinick*** (molinick@middlebury.edu), Department of Mathematics, Warner Hall, Middlebury College, Middlebury, VT 05753. *Sustainability as a Focus for an Introductory Calculus Course.*

Sustainability means meeting the needs of the present without compromising the ability of future generations to meet their own needs. Calculus, with its powerful tools to examine change, provides an effective means to investigate sustainability questions. We will outline a proposed introductory calculus course in a liberal arts setting which brings these issues to the forefront. The course emphasizes working with real world data sets, model building and analysis, and curve fitting. Some specific questions we will examine include: How fast is the world population increasing? If we continuously release a pollutant into a lake at a known rate, what's the total amount of pollutant that will be dumped into the water in the next five years? How long will the nonrenewable supplies of coal and oil last if we maintain the current per capita use but population continues to grow? How long will supplies last if industrialization and a "rising standard of living" push per capita usage ever higher? If we disturb the natural population dynamics of a salmon species by fishing, how should we regulate our removal of fish to provide a maximal sustainable yield in the future? (Received September 20, 2009)

1056-P1-1276 **Judith Moran*** (judith.moran@trincoll.edu), Aetna Quantitative Center, Trinity College, Summit Street, Hartford, CT 06106. *Using QL Modules to Analyze and Present Large Data Sets in a Winter Ecology Course.* Preliminary report.

Trinity College faculty members Judith Moran Director of the Quantitative Center and Scott Smedley Professor of Biology have worked together preparing a series of three QL modules for Biology 111, Winter Ecology. As part of this course, students study micro-environments by placing thermal loggers in selected locations at a field site. The goal of these modules is to give students the mathematical skills they need to analyze the large data sets consisting of hourly temperature readings that are collected and recorded by each thermal logger over a period of several months. The three QL modules are: 1) Introduction to Excel spread sheets and graphing, 2) Mechanisms of interpreting, critiquing and presenting graphs, 3) Statistical significance and hypothesis testing using t-tests. Materials from the QL modules and examples of the final student data analyses and presentations will be distributed. (Received September 21, 2009)

1056-P1-1312 **Jan O. Case*** (jcase@jsu.edu), MCIS Department, Jacksonville State University, 700 Pelham Road North, Jacksonville, AL 36265, and **Scott W. Beckett** (sbeckett@jsu.edu), Learning Services, Jacksonville State University, Jacksonville, AL 36265. *Could i-Tree Software Have Helped the Lorax?*

In a sleepy little Southern town, not so long ago, a tale played out that was remarkably similar to Dr. Seuss' book, The Lorax. In the children's book, first published in 1971, a "mossy, bossy, man-like creature" introduces himself with the phrase, "I am the Lorax. I speak for the trees. I speak for the trees for the trees have no tongues." In Jacksonville, Alabama a most lively confrontation developed over three seventy-year-old pecan trees. The contestants were the Alabama Power Company versus a handful of residents who were determined to speak for the trees. In the ensuing drama over the utility company's desire to fell the trees and the homeowners' desire to keep them standing, many opinions and arguments were voiced through media outlets in the city. One of the most interesting viewpoints was a quantitative approach to determine the value of the trees. Using i-Tree, a free, peer-reviewed software suite from the USDA Forest Service that provides urban forestry analysis and benefits assessment tools, data was collected and a cost-benefit analysis was provided. In addition to contributing valuable information to a local controversy, the investigation provided an excellent classroom example of the use of quantitative literacy towards an environmental issue. (Received September 21, 2009)

1056-P1-1610 **Thomas J Pfaff*** (tpfaff@ithaca.edu), Mathematics Department, Ithaca College, Ithaca, NY 14850. *Raising Awareness of Environmental Issues in Statistics Course.* Preliminary report.

If we go with the assumption that we can't change the statistics curriculum (this is a topic for a different day) then we will need to find environmental examples that fit the curriculum. With this is mind, we give some examples of exercises for statistics classes that fit the curriculum and address environmental issues at the same time. Along the way we will talk more broadly about finding and adapting environmental or quantitative reasoning problems for statistics. (Received September 22, 2009)

1056-P1-1639 **Ben Steele*** (bsteele@colby-sawyer.edu), Department of Natural Sciences, 541 Main Street, New London, NH 03257, **Semra Kilic-Bahi**, Department of Natural Sciences, New London, NH 03257, **Nick Baer**, Department of Natural Sciences, New London, NH 03257, **Leon Malan**, Department of Environmental Studies, New London, NH 03257, **Laura Alexander**, Department of Environmental Studies, New London, NH 02357, and **Harvey Pine**, Department of Environmental Studies, New London, NH 03257. *An Across-the-Curriculum Approach to Quantitative Literacy in Environmental Studies.*

At Colby-Sawyer College, students in Environmental Studies and Environmental Science take one math course, Introduction to Statistics, but to prepare them for careers or graduate study in this quantitatively rich field, we present them with other quantitative problems in a variety of courses. Even though the required mathematical skills are elementary, students learn how to apply the concepts in a variety of settings. The two major uses of mathematical concepts are in data analysis and in modeling, and the use of spreadsheets complements the math. Complexity generally builds through the four years and the third year project, a year long, real world, group investigation, and the individual capstone project often require significant use of numbers. A curriculum grid maps concepts through different courses. This approach does not guarantee that every student receives instruction in all relevant concepts, but student's progress is monitored by a QL test given to all first year students and all seniors. (Received September 22, 2009)

1056-P1-1948 **John C. Nardo*** (jnardo@oglethorpe.edu), Oglethorpe University, 4484 Peachtree Rd. NE, Atlanta, GA 30319, and **Judith Lynn Gieger** (lgieger@oglethorpe.edu), Oglethorpe University, 4484 Peachtree Rd. NE, Atlanta, GA 30319. *Water, Water, Everywhere–Even in Statistics.*

Science Education for New Civic Engagements and Responsibilities (SENCER) was established in 2001 to support an ever-growing community of those seeking to improve undergraduate STEM (science, technology, engineering and mathematics) education by connecting learning to critical civic questions. During the spring semester of 2009 the Oglethorpe SENCER team organized a three-way course intersection (involving students in introductory statistics, chemistry, and physics courses) to gather water quality data. The data collection was a required component for students in each of their respective courses. The topic of water quality was chosen because it is a capacious and unresolved problem that affects so many aspects of life. This project allowed students to experience actually collecting a non-trivial sample and to see the power of using mathematics to understand real-world problems; therefore, they became greater stakeholders in this important issue. In addition to describing SENCER's goals and the practical aspects of conducting such a course intersection, we will also discuss our expansion plans to involve students in the analysis of this data, additional data collection, and dissemination of results. (Received September 22, 2009)

1056-P1-1997 **Ben Fusaro*** (fusaro@math.fsu.edu), Department of mathematics, Florida State University, Tallahassee, FL 32306-4510. *The Environment, Mathematics and Our Community Role.*

The struggle between civic or environment organizations and developers presents many opportunities to contribute to our communities and to show that mathematics is useful. How...? By being a volunteer consultant for organizations such as Audubon, the Sierra Club, or for local civic groups. A college mathematics teacher with an elementary knowledge of chemistry or physics is in a good position to help. Almost all local or regional environmental issues require little beyond a rudimentary knowledge of geometry, probability, growth functions, and skill in representing issues and results in visual form. It is easy to explain an issue to an individual or to a small group. Public hearings can come across as intimidating but it's not very different from giving a lecture to one's colleagues. The developers' experts are often biologists or engineers (used mainly to impress the commissioners & audience) but they have a healthy respect for mathematicians with a graduate degree. I will give suggestions on getting started as a volunteer consultant and will provide several examples from my own 12 years of experience. The examples will deal with such issues as resisting the paving-over of a stream, protecting cypress trees from being turned into mulch, and defeating a polluting power plant. (Received September 22, 2009)

# Research on the Teaching and Learning of Undergraduate Mathematics

1056-P5-32 **Douglas Quinney*** (d.a.quinney@keele.ac.uk), School of Computing and Mathematics, University of Keele, Keele, ST5 5BG, England. *The role of e-assessment in student learning in mathematics.* Preliminary report.

It is often commented that assessment drives learning and over recent years there has been a drive to use computer based assessment (CBS) schemes in both formative and summative assessment. There is substantial evidence to support claims that e-assessment has reduced staff loads by reducing marking time, reduced central support staff time, and provided means where administration staff can compile results and collate statistics more easily. But do they really help students to acquire deep understanding and thus promote learning?

A recent reorganization at Keele Univrsity, UK, involves the combination of two parallel mathematics courses, one a traditional course taught by "Chalk and talk" and the other a computed based course delivered using only a VLE and CBS. This gives an opportunity to embed e-assessment as the course is designed by comparing the outcomes assessment, and also with previous years. This paper will present some of the preliminary results from this investigation in terms of the efficacy of this approach and, more fundamentally, in any changes to student learning. (Received July 03, 2009)

1056-P5-184 **Tim Fukawa-Connelly*** (tim.fc@unh.edu), Department of Mathematics and Statistics, Kingsbury Hall W348, University of New Hampshire, Durham, NH 03824. *An Example of a Non-traditional Pedagogy in an Abstract Algebra Class: What is the effect on student motivation?*

It is important to develop a better understanding of the fine-grained mechanisms, such as students' attitudes and beliefs, by which they make the day-to-day decisions about their work that contribute to their success (or lack thereof). This need to better understand student motivation extends to advanced mathematics classes at the university level as retention of students interested in mathematics and mathematics education is important. The unique abstract algebra class described in this study can provide insight into socio-mathematical norms and classroom practices that supported students' academically successful decision-making processes. In particular, it uses the lens of Collective Cognitive Responsibility (Scardamalia, 2002) to better understand the norms and practices that contributed to students' academic success. This paper provides an analysis of interviews and classroom vignettes that may suggest instructional strategies that better support students' development of the types of motivation that lead to academic success in the context of advanced mathematics. (Received August 13, 2009)

1056-P5-303 **Eric D Weber*** (webered2009@gmail.com) and **Marilyn P Carlson** (marilyn.carlson@asu.edu). *The Role of Homework in Developing Students' Mathematical Conceptions.* Preliminary report.

The rate at which the United States has lost students in STEM majors has proven so severe that policymakers are calling for colleges and universities to understand and address the problem (Business Higher Education Forum, 2007). In many courses, advanced mathematical learning takes place outside of the classroom (NCTM, 2000). However, a review of major science and mathematics education literature reveals there are currently no studies that evaluate how the design of out of class assignments elicits specific reasoning patterns in students. After developing new materials for teachers of pre-calculus it was apparent that homework was an area of learning to which many textbooks, and researchers had paid little attention. This investigation proposed to study homework's role in developing students' mathematical conceptions within pre-calculus and calculus courses. The ongoing study aims to give insight into how both teachers and students use homework as learning tool, to provide a window into the appropriate content of homework problem sets, and how to engage students in order to promote spontaneous and creative methods of problem solving while outside a formal classroom setting. (Received August 27, 2009)

1056-P5-446 **May F Hamdan*** (mhamdan@lau.edu.lb), LAU, POBox 13-5053/F64, Beirut, 13-5053/F6, Lebanon. *Parameter or variable or unknown? The special case of the definite integral.* Preliminary report.

In this report I discuss the difficulties students have with understanding the differences between a parameter, an index, and a variable. How do students understand the difference between a determinate, an indeterminate and an unknown? Which of these "values" are temporary indicators? I study these differences through the genetic decomposition of Riemann sums (Transcribing an Animation: The case of the Riemann Sums: May Hamdan, appeared in the proceedings of the September 2009 10th International Conference "Models in Developing Mathematics Education"). The large number of referents in the formula of the rieman sums as a limit of an infinite sum tends to be confusing. What do all those refernens represent? How do they differ in nature? Which depend on the other? Will they eventually have one value. These questions lead to studying how students comprehend the parameter as a placeholder which is changing Index (temporary) yet it remains indeterminate in that it is not subjected to an inquisitorial procedure that would reveal its hidden numeric identity. Others understand it as a generalizer, an implicit value that is conceptually more difficult than a variable. A rather generic organizer used mostly in the description of a (dynamic) process. (Received September 07, 2009)

1056-P5-622 **Stan T Yoshinobu*** (styoshin@calpoly.edu), 1675 Southwood Drive, San Luis Obispo, CA 93401. *A Theoretical Framework for Designing Professional Development Workshops for Mathematics Faculty.*

A growing body of evidence exists that suggests student-centered teaching methods are more effective at teaching students to learn mathematics in deep and profound ways. Mathematics faculty at colleges and universities often have few opportunities to learn about and to use student-centered teaching methods, such as Inquiry-Based Learning. Although teaching is one of the primary jobs for faculty, "on-the-job" training programs are often short, targeted to a wide audience, and do not adequately address critical obstacles to instructor change.

It is argued that the quality of the training faculty experience can significantly impact the learning experiences for undergraduates. Thus professional development plays a significant role in undergraduate Mathematics Education research and in pragmatic educational policy.

In this talk a theoretical framework is presented that specifically targets key obstacles to instructor change. Results from workshops designed using this framework will be discussed, as well as possible adaptations of the framework and further directions of work. (Received September 14, 2009)

1056-P5-671 **Kevin C. Moore*** (kmzipsgolf@gmail.com), 1522 S River Dr, Tempe, AZ 85281. *The Role of Angle Measure and the Radius as a Unit of Measurement in Developing Coherent Understandings of Trigonometric Functions.*

This study investigated precalculus students' conceptions of angle measure, radian as a unit of measurement, and trigonometric functions, as the students engaged with research-based precalculus materials. The precalculus curriculum focused on developing quantitative and covariational reasoning abilities, as well as other understandings deemed foundational to trigonometry. This included engaging students in making meaning of applied problems, identifying varying and fixed quantities in an applied context, and formalizing the quantitative relationships conceived from the problems' context. Results from this investigation revealed that ideas of angle measure and the radian are foundational for developing coherent understandings of trigonometric functions across the various contexts of trigonometry. Specifically, these ideas were necessary for reasoning about the geometric objects of trigonometry (e.g., right triangles and the unit circle). Many student difficulties resulted from the mental images they developed of the quantities and their units of measurements. It was revealed to be important that the students conceived of the quantities and the meaning of the units used to measure these quantities (e.g., radians) before reasoning about relationships between the quantities. (Received September 15, 2009)

1056-P5-680 **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, and **Matthew Leingang** (leingang@cims.nyu.ed), Courant Institute of Mathematical Science, Warren Weaver Hall 624, 251 Mercer Street, New York, NY 10012. *How beginning teachers understand student thinking in calculus.* Preliminary report.

Every teacher of calculus encounters various degrees of student understanding. To be a successful teacher, it is essential to understand student misconceptions and to make clear explanations to one's students. Our project is concerned with how new teachers develop their ability to understand student thinking. We conducted individual interviews with graduate students teaching calculus for the first time. We interviewed each graduate student before and after their first teaching assignment. The interviews were transcribed and coded for analysis. We will present the results of our findings in this talk. Our hope is to provide information to that will be useful in developing more effective teaching training programs for graduate students who will teach undergraduate mathematics. (Received September 15, 2009)

1056-P5-753 **Evan Fuller*** (fullere@montclair.edu), Department of Mathematical Sciences, Montclair State University, 1 Normal Ave, Montclair, NJ 07043, and **Keith Weber**, **Pablo Mejia-Ramos**, **Kathryn Rhoads**, **Robert Search** and **Aron Samkoff**. *Understanding mathematical proofs: What does it mean and how can it be assessed?* Preliminary report.

In advanced mathematical courses, students spend a substantial amount of time reading proofs that appear in their textbooks or are presented to them during lecture. However, what students can learn by reading mathematical proofs, what it means to understand a mathematical proof, and how this understanding can be assessed are all open questions in mathematics education that are in need of research. In practice, students' understanding of a proof is assessed–to the extent it is assessed at all–by asking students to reproduce the proof or make minor adjustments to the proof to prove a similar theorem. In this presentation, we suggest that there are multiple dimensions to understanding a proof. A proof can be understood in terms of aspects that include (a) its logical structure, (b) its high-level ideas or structure, (c) the method that is employed, or (d) how it relates to specific examples.. We also illustrate how each type of understanding can be assessed in the context of a particular proof. (Received September 20, 2009)

1056-P5-1101 **Stacey A. Bowling*** (stacey.bowling@asu.edu), 3678 E Yeager Ct, Gilbert, AZ 85295. *Investigating Student Conceptions of Function Composition.* Preliminary report.

Existing research on function composition has focused on students' ability to solve function composition problems relative to the student's conception of function. However, little research has examined the mental actions and understandings needed to understand and use function composition meaningfully when solving novel problems. This research addresses this gap, investigating the reasoning that facilitates or impedes precalculus students' development of robust understandings of function composition. This study occurred in the setting of a precalculus class, with data collected both in the classroom and in clinical interviews with individual students. The precalculus course materials were research-based and designed from theories of quantitative and covariational reasoning. Data are presented that illustrate how conceptions of function composition are affected by students' mental images, quantitative reasoning, understandings of variable, and understandings of functional relationships and function representations. (Received September 20, 2009)

1056-P5-1151 **Paul Christian Dawkins*** (rdawkins@uta.edu), 3908 Rustic Forest Trl., Arlington, TX 76016. *Clarifying the Stages of Mathematical Defining: Gestation and Presentation.*

Research shows that students generally do not understand definitions the way that mathematicians do, namely that mathematics definitions are stipulated rather than extracted and thus have no truth value (Edwards & Ward, 2008; Selden & Selden, 2008). However, others suggest that even mathematicians have a more complex relationship with definitions and the classroom should reflect this (De Villiers, 1998); Klein for instance advocated classrooms which do not present mathematics as "finished" but rather as in formation using what he called the "bio-genetic principle." Taking a cue from Polya's words, "Mathematics presented with rigor is a systematic and deductive science, but mathematics in gestation is an empirical and inductive science" (Polya, 1944), I suggest an alternate model for thinking of mathematical definitions with two stages: gestation and presentation. Definitions in gestation often have an extracted nature while presented definitions are fully stipulated. I present evidence from instruction that fits this model which was used by a research mathematician in an undergraduate real analysis class as well as the corresponding student thinking about mathematical definitions which arose in this environment. (This work was partially supported by NSF DUE #0837810.) (Received September 22, 2009)

1056-P5-1343 **Yvonne Lai*** (yxl@umich.edu), Department of Mathematics, University of Michigan, Ann Arbor, MI 48104, and **Keith H Weber** (keith.weber@gse.rutgers.edu), Graduate School of Education, Rutgers University, New Brunswick, NJ 08901. *Between construction and communication: What goes into revising a proof?* Preliminary report.

After work on a mathematics problem, one might (be asked to) communicate a solution. Communicating mathematical reasoning is central to teaching practice and has recently gained emphasis in inquiry-based and other reform college classes. Yet what does it mean to communicate proof? What processes and evaluations occur between the construction and communication of proof? What constitutes clarity? Answers to such questions will give guidance to professors on how to improve lectures.

We report analysis based on data from 10 practicing mathematicians. We presented each mathematician with a statement that uniformly took under a minute to validate as true, yet on average more than 10 minutes to finish writing its proof. We then asked each mathematician to revise proofs of a statement that again was validated swiftly yet took care to communicate.

From the mathematicians' working thoughts and interviews, we propose an initial framework for the processes behind and characterization of clear mathematical communication. Time allowing, we may contrast the mathematicians' work with student work on similar tasks. Our results will shed insight into the communicative goals of proof presentation and highlight important aspects of proof that can be emphasized to achieve these goals. (Received September 21, 2009)

1056-P5-1350 **Juan Pablo Mejia Ramos*** (jpmejia@math.rutgers.edu), 10 Seminary Place, New Brunswick, NJ 08904, and **Matthew Inglis**. *Undergraduate students' assessment of the persuasiveness of mathematical arguments: Beyond private and public senses of conviction.*

Several mathematics educators have suggested that there are two different ways in which mathematics undergraduate students proceed when assessing the persuasiveness of a mathematical argument: by evaluating the extent to which it is personally convincing, or by evaluating the extent to which it is publicly acceptable. In this presentation we use Toulmin's (1958) argumentation scheme to describe a more detailed classification of the different ways in which students may assess the persuasiveness of an argument. We suggest that there are (at least) five different ways in which such an evaluation may take place. This classification is illustrated with data from an interview study that tracked the development of students' argument evaluation behavior across the course of an undergraduate mathematics degree. (Received September 21, 2009)

1056-P5-1366 **Christine Larson*** (larson.christy@gmail.com), **Michelle Zandieh** (zandieh@asu.edu), **Chris Rasmussen** (chrisraz@sciences.sdsu.edu) and **Frances Henderson** (fdhender@gmail.com). *Early Eigen Thinking: Students' Interpretations of the Matrix Equation Ax=2x.*

The ideas of eigenvectors and eigenvalues are often introduced in introductory linear algebra courses using matrix equations of the form Ax=2x in low dimensional settings. In this talk, we address the question: How do students think about the matrix equation Ax = 2x? We will discuss students' conceptions of Ax, of 2x, and the ways in which different coordinations of these expressions reflect student conceptions of the equals sign in this context. We believe that students' interpretations of the equals sign in the equation Ax=2x is likely inseparable from their interpretations of Ax and 2x because the way in which one interprets these expressions individually creates constraints and affordances for ways of coordinating relationships between them. Our talk will identify three categories of conceptualizations for matrix multiplication and provide illustrative examples of each. Data was taken from a set of semi-structured clinical interviews conducted with students enrolled in an undergraduate inquiry-oriented introductory linear algebra class. (Received September 21, 2009)

1056-P5-1488 **Stacy A. Brown*** (stacy_brown@pitzer.edu). *Examples, Uncertainty, & Skepticism: An Examination of the Underpinnings of An Intellectual Need for Proof.*

While many researchers have documented undergraduate students' difficulties with mathematical proof (Alibert & Thomas, 1991; Dubinsky, 1989; Fischbein & Engel, 1989; Moore, 1995; Movshovitz-Hadar, 1993) much less is known about the types of situations that facilitate a need for proof in the eyes of the student and about how students might be better enculturated into the practice of proof. Research on the use and role of examples (Balacheff, 1988; Harel & Sowder, 1998; Zazkis & Chernoff, 2008) and on contexts that facilitate uncertainty (Buchbinder & Zaslavsky, 2009; Zaslavsky, 2008) provide two promising avenues for exploring the types of situations that facilitate a need for and understanding of proof. In this talk, I will examine these two avenues and argue that a third avenue, which works in conjunction with the first two, is necessary; namely, research on the development of skepticism in mathematical contexts. (Received September 22, 2009)

1056-P5-1568 **Carlos W Castillo-Garsow*** (cwcg@asu.edu), Arizona State University, RIMSE, PO BOX 873604, Tempe, AZ 85287-3604. *Learning the phase plane: How two students' understandings of time and rate affected their learning of exponential functions.*

The exponential property, that a quantity's rate of change is proportional to the value of the quantity, can be graphed as a phase plane diagram. In a phase plane diagram, time is implicit, and the diagram itself describes the relationship between a quantity and its rate of change. In order to use a phase plane diagram to describe the relationship of the quantity to time, a student must bring to the diagram their understandings of the interactions between time, the quantity, and the quantity's rate of change.

Derek and Tiffany are high school Algebra II students. Tiffany thinks about time passing in "chunks." For her, a month is an interval of time made up of 30 days. Her understanding of 60 miles per hour is that an hour passed and the car drove 60 miles. Derek thinks of time as continuously changing. His understanding of 60 miles per hour is that distance and time are always changing, and that they are always proportional.

This paper will discuss how Derek and Tiffany's understandings of time and rate affected their reasoning about the phase plane diagram when asked to use that diagram to make a graph of the quantity with respect to time, as well as potential ramifications for teaching the relationship between the exponential property and exponential growth. (Received September 22, 2009)

1056-P5-1692 **Rebecca H McGraw*** (rmcgraw@math.arizona.edu), 617 N Santa Rita Ave, Tucson, AZ 85721, and **Priya Prasad**. *Researching the Integration of Mathematical and Educational Perspectives in Mathematics Teacher Preparation.* Preliminary report.

Improving mathematics teacher preparation requires the combined attention of faculty who teach future teachers – namely, mathematicians and mathematics teacher educators. However, jurisdiction over teacher preparation is often divided across separate and distinct academic units, and administrative and cultural barriers impede communication and joint work. The separation of these disciplines is reflected in the separation of mathematics learning from the learning of pedagogy in teacher preparation. Our research focuses on the work of mathematicians and mathematics teacher educators who attempt to overcome such barriers by co-teaching courses for future secondary mathematics teachers, with an explicit focus on integrating the learning of mathematics with the learning of pedagogy. The research is ongoing, however several themes related to collaborating across disciplinary boundaries have been identified, including (1) asymmetries in the structure and process of collaboration that may be due to differences in disciplinary cultures, (2) similarities and differences across disciplines with respect to the relationships among teachers, students, and course content, and (3) outcomes of collaboration, particularly the development of specific methods for integrating content and pedagogy. (Received September 22, 2009)

1056-P5-1694 **Marja-Liisa Hassi*** (hassi@colorado.edu), Ethnography & Evaluation Research/CARTSS, University of Colorado at Boulder, 580 UCB, Boulder, CO 80309-0580, and **Sandra Laursen** and **Anne-Barrie Hunter**. *Enhancing Undergraduate Students' Views and Experiences of Learning Mathematics in Inquiry-Based Learning Contexts.*

This presentation will focus on undergraduate students' self-reported gains in college mathematics courses and how these relate to the use of inquiry-based learning (IBL) methods in their courses. Students' experiences will be reported against the development of their beliefs, motivation and strategies for learning and solving mathematical problems. Our pre- and post- survey data from over 30 courses on four campuses showed that students found IBL instructional practices beneficial and reported cognitive, affective and social gains that differed from those reported by students in comparative (non-IBL) mathematics sections. Clear positive correlations link students' self-reported learning gains with their experiences of instructional practices and with classroom practices observed by external observers. Positive changes from pre- to post-surveys in beliefs, motivation and strategies indicate the positive impact of IBL teaching methods on students' perceptions and practices in studying college mathematics. The nature and extent of these impacts vary by student groups and also reflect variation in instructor styles of implementing inquiry-based learning methods, as measured in classroom observation data. (Received September 22, 2009)

1056-P5-1952 **Jessica L Knapp*** (jessica.knapp@pima.edu), Pima Community College, 7600 N Shannon Rd, Tucson, AZ 85709. *Appropriating New Definitions: The Case of Lipschitz Functions.*

Learning new definitions is a vital skill for mathematics students. This paper seeks to describe several ways that junior mathematics students approached a new definition in a real analysis context. Students explored the definition by sketching graphs, re-wording the statement, looking for examples, negating the statement, finding non-examples and relating it to definitions students had already encountered. Some of these tasks proved more fruitful than others. (Received September 22, 2009)

1056-P5-1956 **Jim Brandt*** (brandt@suu.edu), Southern Utah University, 351 W University Blvd, Cedar City, UT 84720. *Students' Understandings of Equivalence Relations.*

The notion of equivalence plays a role in understanding relationships between a wide variety of mathematical objects, such as fractions, equations, and vectors. This fundamental idea is formalized in the notion of an equivalence relation. In attempting to assess student difficulties with equivalence relations, task-based interviews were conducted with 17 undergraduate students enrolled in either a lower division discrete mathematics course or an upper division transition-to-proofs course. Students were asked conceptual questions about equivalence relations and equivalence classes, and then attempted to prove or disprove that particular relations were equivalence relations. Common approaches to these tasks as well as student misconceptions will be discussed and related to research involving proofs. Given the difficulty that many students have in moving from informal concepts to formal arguments, comparisons between the two classes will be emphasized. (Received September 22, 2009)

1056-P5-2022 **Angie Hodge*** (Angela.Hodge@ndsu.edu) and **Ryan Hiltner**. *Examining Undergraduate Students' Reading and Use of Mathematics Textbooks.*

This session will report the results from a study that investigated student textbook use in undergraduate mathematics classes. Students from both Abstract Algebra and Calculus were surveyed near the end of the semester, and data were analyzed to determine the differences and similarities in students' habits in relation to the use of their textbooks. Descriptive statistics coupled with open-ended responses to survey questions were used to compare how and when students at these two levels of mathematics used and read their mathematics textbooks. This session will discuss the findings from the study and implications for the teaching and learning of undergraduate mathematics. (Received September 22, 2009)

1056-P5-2068 **Kyeong Hah Roh*** (khroh@math.asu.edu), School of, Mathematical and Statistical Sciences, Tempe, AZ 85287. *A design of instructional interventions for the resolution of cognitive dissonance in an advanced calculus class.*

This study examines how instructional interventions help students experience and resolve cognitive dissonance, especially in undergraduate mathematics courses. In particular, this study focuses on the nature and its role of the $\varepsilon-$strip activity in studying the $\varepsilon - N$ definition. The study was conducted as part of a larger study from a semester long teaching experiment at a public university. The subjects of the study was mathematics students in an advanced calculus course. Students in the course worked in small groups with proper guidance from their instructor. Dewey's theory of reflective thinking was used in the analysis of the data. The students in the study initially experienced cognitive dissonance due to the discrepancy between their preconceived notion of limit and the $\varepsilon - N$ definition. However, their cognitive dissonance was resolved as they engaged in the $\varepsilon-$strip activity. Furthermore, a proper image of limit was formed through the $\varepsilon-$strip activity, and the students continued reflecting on the $\varepsilon-$strip activity while determining convergence of sequences, and proving properties of convergent sequences in $\mathbb{R}$. (Received September 23, 2009)

# *Scholarship of Teaching and Learning in Undergraduate Mathematics*

1056-Q1-243 **Kien H. Lim*** (kienlim@utep.edu), Department of Mathematical Sciences, 500 W. University Ave, University of Texas at El Paso, El Paso, TX 79968-0514. *Helping Pre-Service Teachers Address their Tendency of Overgeneralizing Proportionality: Using Non-proportional Situations and Focusing on Quantities and Relationships.*

Many pre-service teachers have a disposition to spontaneously proceed with an action that comes to mind without analyzing the problem situation, especially in the domain of ratios and proportions. Research has shown that students tend to overgeneralize proportionality in solving missing-value problems. A study involving two sections of a math course for pre-service 4-8 teachers was conducted to investigate the short-term impact of using non-proportional missing-value problems to minimize their improper use of proportional strategies, and to explore the possibility of helping them improve their disposition–from being impulsive to being analytic–in one semester. Lessons were designed whenever possible to help them become cognizant of their impulsive disposition. For example, non-ratio comparison problems were posed after they had experienced working on problems that involve comparing ratios. Quantitative reasoning was emphasized throughout the semester. Some test items were designed to be superficially similar but structurally different from those done in class or homework. Results show that students' tendency to overuse ratios and proportions was reduced in one semester and that the use of non-proportional situations did minimize students' overgeneralization of proportionality. (Received September 08, 2009)

1056-Q1-342 **Claus Schubert*** (claus.schubert@cortland.edu), Dept. of Mathematics, SUNY Cortland, Cortland, NY 13045, and **Mary Gfeller** (mary.gfeller@cortland.edu), Dept. of Mathematics, SUNY Cortland, Cortland, NY 13045. *Teaching Abstract Algebra using Technology.* Preliminary report.

This talk describes experiences using technology in a first undergraduate abstract algebra course. Students were surveyed about the effectiveness of technology in their learning in general and this course in particular. We also investigated a possible correlation between the students' perceived benefit of the technology and their answers to content questions in exams. (Received August 31, 2009)

1056-Q1-648 **Mary A Nelson*** (mary.nelson@colorado.edu), Applied Mathematics Department, Box 526, University of Colorado, Colorado Blvd, Boulder, CO 80309, and **Monica R Geist** (monica.geist@frontrange.edu), Mathematics Department, 3645 W. 112th Avenue, Westminster, CO 80031. *Success in Calculus I: Oral Reviews.*

This paper reports on an innovative approach to teaching calculus which is being used in large Calculus I and II classes in order to help students develop a deeper understanding of the critical concepts, resulting in improved ability to apply knowledge to novel situations. The treatment consists of voluntary oral reviews which take place before every written unit exam. Five students meet with a facilitator who asks them conceptual questions and requires them to defend their reasoning and negotiate meaning.

Students participating in 3 orals had average course grades nearly a letter grade higher than those of the control in both 2007 and 2008. Motivation measures indicate that motivation does not account for the differences seen. In both Fall 07/08, students were classified in four different ability groups as determined by a placement test that has been validated. Within each ability group, statistically significant differences were seen between students who took no orals and those who took three orals.

Mechanical Engineering introduced oral assessments in Spring 2009 and saw a 5% difference in the grades of those who did and did not participate in orals, and Aerospace Engineering has introduced orals into an introductory course this fall. (Received September 15, 2009)

1056-Q1-1052 **Ellen F Hill*** (elhill@mnstate.edu), Minnesota State University Moorhead, 1104 Seventh Ave. S., Moorhead, MN 56563. *Results of the use of guided notes and lab work in introductory college courses.*

Guided notes are a lecture technique using pre-printed outlines of lectures that are filled in with the class. In Business Calculus and College Algebra, guided notes were used to deliver the mathematical content during the first part of each class meeting, and the second part of the period was reserved for in-class work on worksheets (called labs) on the same material. A common concern with the use of guided notes is reduced retention of the mathematical content by the students. Comparative results will be given on the overall class averages on cumulative final exams, individual final exam questions, and student course evaluations between sections not using guided notes and sections where guided notes were used. (Received September 20, 2009)

1056-Q1-1060 **Diane Fisher*** (dfisher@louisiana.edu), Department of Mathematics, P.O. Box 41010, Lafayette, LA 70504, and **Jennifer Kaplan** and **Neal Rogness**. *What Do Students Hear in Statistics Classes: Empirical Results from a Study of Lexical Ambiguity.* Preliminary report.

Language plays a crucial role in the classroom. The use of specialized language in a domain can cause a subject to seem more difficult for students than it actually is and impede students from learning what we hope they will learn. Everyday English words that are used differently in a domain are said to have lexical ambiguity. The presentation is part of a sequence of studies designed to understand the effects of and develop techniques for exploiting lexical ambiguities in the statistics classroom. The talk will present a method for studying language use by undergraduate students and empirical results of students' pre-existing and developed definitions of words used in introductory level statistics classes. (Received September 20, 2009)

1056-Q1-1177 **Jinfeng Wei*** (jwei@maryville.edu), 650 Maryville University Dr., St. Louis, MO 63141, and **Guangwei Fan** and **Min Deng**. *Teaching Reform in College Algebra.* Preliminary report.

In College Algebra course, most of the students are either business or social work majors who are taking the course with the primary goal of applying the concepts in other courses. Students often arrive with poor attitudes toward the subject because of past undesirable mathematical experiences. An effective strategy to teach such students is to firstly create a comfortable atmosphere to interest them. Another common problem in this course is that most of students have trouble with story problems. To improve student's mathematical thinking and ability to solve problems, I emphasized on teaching how to analyze and solve story problems in class and changed the regular weekly in-class quizzes to projects presentations. The students evaluated the reform as an effective teaching style to improve their ability of problem solving. (Received September 21, 2009)

1056-Q1-1267 **Harold B Reiter*** (hbreiter@uncc.edu), Department of Mathematics, UNC Charlotte, 9201 University City Blvd, Charlotte, NC 28223, and **Anthony Fernandes** (Anthony.Fernandes@uncc.edu), same as above. *Mathematics Teachers' Circles.* Preliminary report.

The Mathematics Teachers' Circle is a national initiative started in 2006 by the American Institute of Mathematics (AIM). This initiative is based on the premise that engaging Middle school teachers in mathematical problem solving will enhance their content knowledge of mathematics, help them experience the challenge of solving a new problem, and provide a support system and resources for the teachers. At the local Circles, teachers attend monthly meetings where the facilitators engage through appropriate problems. The teachers work in interactive groups as the facilitators move around and listen to ideas and provide needed input. Later teachers have a chance to share their strategies with the entire group. Special efforts are made to ensure that the teachers are comfortable sharing their mathematical ideas with their peers and in the presence of the facilitators. We will discuss the set-up of one local Teachers' Circle, engage the audience in a problem solving experience, discuss the benefits reported by teachers, and the challenges faced by the facilitators. The audience would get a glimpse of how to set up their own local Circle, plug in to the larger Teachers' Circle network, and see how productive collaboration between mathematicians and teachers can work. (Received September 21, 2009)

1056-Q1-1549 **Stephen D. Szydlik*** (`szydliks@uwosh.edu`), Mathematics Department, UW-Oshkosh, 800 Algoma Blvd., Oshkosh, WI 54901. *Beliefs of Liberal Arts Mathematics Students Regarding the Nature of Mathematics.* Preliminary report.

The research literature suggests that student beliefs about the nature of mathematics tend to be very different from those of mathematicians. While mathematics professionals broadly view mathematics as a coherent and logical discipline, novice students often see the subject as a body of facts and procedures that are at best loosely connected. This latter perspective leads to an "impoverished" mathematics, a view that success in math consists of mastering a corpus of mathematical facts and procedures (Schoenfeld, 1992). While research on the mathematical beliefs of prospective teachers is extensive, the views of lower-level collegiate mathematics students have been much less studied. In the SoTL research presented in this talk, we investigate the mathematical beliefs of liberal arts students regarding the nature of mathematics. We also attempt to measure whether those beliefs and attitudes are meaningfully changed during a semester-long, problem-based mathematics course. (Received September 22, 2009)

1056-Q1-1594 **Fabiana Cardetti*** (`fabiana.cardetti@uconn.edu`), 196 auditorium Rd, unit 3009, storrs, CT 06268, and **P. Joseph McKenna**. *Anatomy of a multi-section calculus semester: A students-eye view.* Preliminary report.

In this talk, we will present the results of an exploration of the common learning experiences across many different sections of the same mathematics course. Our findings are based on students' journal reflections kept during a full semester and collected over the last four years. Upon reading the students' writings we were surprised to find that regardless of the particular semester (fall or spring) and the particular course section, a cycle emerged on the students' academic lives. Our analysis rendered a break down of the semester into four distinct periods affecting the students' learning experience. In this presentation we will share descriptions of the different periods in the students' own words, as well as offer suggestions for teaching practices aimed at improving student-learning outcomes based on our findings. (Received September 22, 2009)

1056-Q1-1629 **Joy Moore*** (`moorej12@xavier.edu`), Xavier University, Department of Mathematics & Computer Science, 3800 Victory Parkway Mail Location 4441, Cincinnati, OH 45207-4441, and **Bernd Rossa** (`rossa@xavier.edu`), Xavier University, Department of Mathematics & Computer Science, 3800 Victory Parkway, Cincinnati, OH 45207-4441. *A Modified Moore Method in Real Analysis: Hearing the Students' Voices.* Preliminary report.

This paper relates the results of a collaborative pilot study between a mathematician who teaches real analysis and a mathematics educator who investigates student learning. At Xavier University in Cincinnati, OH, Dr. Rossa began using a modified Moore Method of instruction in his real analysis course four years ago. In the spring semester of 2009, he collaborated with Dr. Moore, a mathematics education colleague, to formally investigate the impact of the course from the students' perspective. This qualitative study involves interviews with students, classroom observations, and reflective journal notes from the instructor. Research questions include: What effect has the modified Moore method of instruction had on student learning? Analysis reveals six themes addressed by students: a) descriptions of the course; b) advantages of the pedagogy; c) disadvantages of the pedagogy; d) board presentations: duality of role as presenter and as audience; e) mathematics education: impact on their own teaching opportunities and f) impact on learning experiences in other courses. Results of this pilot study have assisted in refining the quest toward identifying the characteristic value that is particular to the Moore method of teaching. (Received September 22, 2009)

1056-Q1-1695 **Kenneth Horton*** (kenneth.horton1@usafa.edu), Department of Mathematical Sciences, USAF Academy, CO 80840. *Student-Generated Note Cards: Sound Pedagogy?* Preliminary report.

Many college mathematics teachers allow students to generate their own note cards for exams. The intention seems to be to encourage synthesis, organization, reflection, and, perhaps, to ease memorization. How students approach and perceive this task may be far different from their instructor's expectation. In this study, fifty randomly selected student-generated note cards from Calculus II were analyzed across several categories. We discuss the results of this analysis and offer some suggestions for improving the pedagogical value of having students write their own note cards. (Received September 22, 2009)

1056-Q1-1732 **Edwin Prine Herman*** (eherman@uwsp.edu), Department of Mathematics, University of Wisconsin-Stevens Point, Stevens Poiont, WI 54481. *Do discussion boards improve statistical reasoning skills?* Preliminary report.

Last spring I revamped my Introduction to Statistics course, shifting the focus from acquisition of methods to their application. I added readings on major topics (such as Global Warming and the Economy) and had students post comments and analysis in small discussion boards. Every few weeks, students would then write short papers on the topics, using statistics to support their arguments. The purpose of the discussion boards was to improve the statistical reasoning skills of the students by having them discuss ideas and facts with each other. If the boards were successful, student papers should show evidence of ideas posted by other students. Analysis of this evidence will be presented, as will student perceptions of the effectiveness of the boards and papers in teaching statistical ideas and methods. (Received September 22, 2009)

1056-Q1-1748 **Bernadette F. Turner*** (turnerb@lincolnu.edu), Dept. CSTM 820 Chestnut St, Jefferson City, MO 65101, and **Donna Stallings**. *Retention Benefits of Refocused College Algebra.*

Refocused College Algebra is part of an NSF Grant funded to Don Small at West Point Military Academy. The focus of this approach is to combine ideas of statistical analysis with the ordinary algebraic manipulations and analysis of College Algebra in mathematical applications. This grant was specifically designed to study the effects of refocusing on retention in College Algebra classes for HBCU institutions throughout the United States. During the workshop criteria for a cohesive reform curriculum were presented. This has influenced our approach to improving/refocusing other classes as well. Thus syllabus, exams, and homework coincide so that testing and teaching what is stated in goals and objectives is carefully constructed as part of the syllabus. (Received September 22, 2009)

1056-Q1-1773 **Gary Fowler** and **Sommer Gentry*** (gentry@usna.edu), 572-C Holloway Road, Mailstop 9E, Annapolis, MD 21402, and **Amy Ksir** and **Will Traves**. *Calculus Acquisition through a Problem and Activity Based Learning Experience (CAPABLE).* Preliminary report.

The U.S. Naval Academy has begun an experiment to incorporate active-engagement activities such as guided worksheet projects for individual and cooperative use in required calculus courses. By creating new projects and aligning existing project resources with the standard syllabus, the team encouraged instructors to select from a wide range of activities and spend less class time using traditional lecture instructional methods. Students took a survey, before and after the first semester calculus course,about their perceptions of mathematics, mathematical self-efficacy, intellectual autonomy and study skills. Instructors kept a time use log to quantify changes in the classroom environment, reporting time spent variously on classroom discussion, group activity, individual activity, and exposition. This preliminary report will present typical project worksheets, review student and faculty survey results, and demonstrate to what degree instructors adopted active-engagement strategies. (Received September 22, 2009)

1056-Q1-1803 **Nermin Tosmur - Bayazit*** (nbayazit@gsu.edu), 30 Pryor Street, Suite 609, Atlanta, GA 30302. *How Prospective Mathematics Teachers Define Mathematical Definitions*

This study investigated prospective mathematics teachers' conceptions of mathematics, proof and mathematical definition. Individual interviews were conducted with seven prospective mathematics teachers for data collection. The results of the study revealed that participants struggle with the basic terminology related to proof and mathematical definition. Moreover, the way prospective mathematics teachers define mathematical definition was dramatically different than a mathematician's definition of the term. (Received September 22, 2009)

1056-Q1-2007 **Joyati Debnath*** (jdebnath@winona.edu), Mathematics & Statistics, Winona State University, Winona, MN 55987. *Strategies that worked for me in Teaching and Learning Undergraduate Mathematics.*

As we know that the scholarship of teaching and learning involves systematic study of teaching and/or learning, public sharing, and the review of such work through presentations and/or publications. Systematic study involves deeper understanding of the theory of knowledge in a discipline as well as being interdisciplinary. There are many teaching and learning strategies that can be implemented effectively for helping students to learn more successfully in undergraduate mathematics. In this presentation I will discuss my research on this area, how I applied them, and I assessed them while teaching different level of undergraduate mathematics at Winona State University. (Received September 22, 2009)

1056-Q1-2015 **John C. Merkel*** (john.merkel@gmail.com). *Peer Led Team Learning in Calculus I: A four year study.*

In Peer-Led Team Learning (PLTL), teams of 4-6 students engage in collaborative learning guided by a peer leader. Peer leaders, who attend a training workshop and work closely with the instructors, are students who have successfully completed the course. Since 2006, Morehouse College, an all-male HBCU, has implemented PLTL in calculus I courses. Our data, collected over four years, suggests that PLTL students show larger learning gains than their non-PLTL peers. We also report on student attitudes toward PLTL and the effect of PLTL on student retention. (Received September 22, 2009)

1056-Q1-2046 **Paula A. Shorter*** (paula.shorter@rockhurst.edu) and **Mairead K. Greene** (mairead.greene@rockhurst.edu). *Creating Student Centered, Active Learning Classrooms in a Multi-Section Precalculus Course.*

Each fall semester our department offers eight sections of precalculus. All sections share a common syllabus, common schedule, and common student materials in order to achieve a shared active learning experience for all of our precalc students. Student materials include in-class activities designed to engage students in active investigations that build deep understanding of concepts and a semester-long, multi-stage, modeling project. In the past, different sections have experienced varying levels of success in creating an effective active learning classroom. In this talk we will discuss the strategies that we have employed to provide our instructors with the support necessary to achieve the learning environment that we envision for all of our precalculus students. These strategies include a Precalculus wiki - where student materials, implementation suggestions, and teaching reflections are shared among all precalculus instructors, and weekly instructor meetings in which upcoming content and activities are discussed and modified. Also included in this presentation will be analysis of data from ongoing studies in our department over multiple sections of precalculus on student learning using common exam questions and the PCA, student attitudes, and student population data. (Received September 22, 2009)

# Undergraduate Mathematical Biology

1056-Q5-459 **Timothy Comar*** (tcomar@ben.edu), 5700 College RD, Lisle, IL 60532. *Developing Computational Skills in Biocalculus Courses.* Preliminary report.

The second semester biocalculus course at Benedictine University serves as a hybrid between a second semester calculus course and course designed to prepare students to partake in undergraduate research activities in mathematical biology or other quantitatively oriented areas of the biological sciences. Project activities in this course are designed to integrate mathematics, biology, and the use of computational software to investigate biological models. This presentation will highlight several of the weekly computer laboratory projects and one extended project. The extended project requires students to read original literature, implement a biological mathematical model in a computational platform, prepare a written summary of the mathematics and biology surrounding the particular model, and give an oral presentation of their work. This particular project enables students delve more deeply into a particular model than they can do through a weekly assignment and also develop skills that will be useful in an interdisciplinary research environment. Sample materials from the course will be available in print and online formats. (Received September 08, 2009)

1056-Q5-1402 **Raina S Robeva*** (robeva@sbc.edu) and **Terrell Hodge** (terrell.hodge@wmich.edu). *Introductory Mathematical Biology through Finite Dynamical Systems.*

There is a growing number of programs that utilize difference and differential equations models as an introduction to mathematical modeling in biology. The approach is particularly common in pre-calculus and introductory calculus courses. The talk outlines how Boolean Networks and Finite Dynamical Systems could be used as valuable alternatives, especially for students who have not yet entered the calculus sequence and for biology students at institutions where calculus is not required for the biology major. (Received September 21, 2009)

1056-Q5-1530 **S. Minerva Venuti*** (swelling@gmu.edu) and **Padmanabhan Seshaiyer** (pseshaiy@gmu.edu). *Viscoelastic Effects in Biological Soft Tissues.*

In this work, we consider the mathematical modeling and analysis of biological soft-tissues in a fluid structure interaction problem. The associated partial differential equation for the fluid is coupled through the boundary with a viscoelastic structure and is studied using the finite difference method. The numerical solution will be compared against exact solutions that will be obtained using analytical tools such as Laplace Transforms. The effect of viscoelasticity and other bio-mechanical factors will be presented. The mathematical tools presented in this multidisciplinary project can be extended to gain a better insight into problems in the areas of medicine and other related biological problems. (Received September 22, 2009)

1056-Q5-1531 **Jeff R Knisley*** (knisleyj@etsu.edu), Box 70663, Dept. of Math, East Tennessee State University, Johnson City, TN 37614-0663. *Predictive Modeling in Quantitative Biology.*

A predictive model is a mathematical model that predicts the outcome of an experiment or observation, often by estimating a probability distribution for the experimental result. They are used extensively in the sciences, in business, in engineering, and elsewhere for activities such as data mining, reverse engineering, and similar data intensive applications. Indeed, as this presentation will illustrate, predictive modeling as pedagogy addresses most of the recommendations in BIO2010 as well as many recent trends in quantitative biology. Consequently, an interdisciplinary course in predictive modeling at the undergraduate level has become an important component of the Symbiosis Project at East Tennessee State University, and we will describe this course and its outcomes in this presentation. (Received September 22, 2009)

1056-Q5-1676 **Robert C Stolz** (rstolz@uvi.edu), Division of Science and Mathematics, University of the Virgin Islands, St. Thomas, VI 00802, and **Camille A. McKayle*** (cmckayl@uvi.edu), Division of Science and Mathematics, University of the Virgin Islands, St. Thomas, VI 00802. *Interdisciplinary curricular innovations at the University of the Virgin Islands.*

The University of the Virgin Islands, an HBCU, undertook a series of activities in order to transform the undergraduate experience for students with an eye toward integrating mathematical, biological and computational ideas.

The goals of the effort was to increase the quantitative preparedness of all science and mathematics majors, such that they are better able to solve problems using quantitative techniques. In support of this over-arching goals, the objectives were: to introduce quantitative methods into the introductory biology classes and introduce biological applications into introductory quantitative courses; to increase the ability of UVI Division of Science and Mathematics faculty to introduce new quantitative activities and modules into biology courses and new biological application activities and modules into quantitative courses; and to increase the number of students participating in cross disciplinary quantitative science activities in upper level courses or in research each year.

We will present preliminary results, including the formation of new concentrations for all students, the creation of new courses, the creation of and implementation of course modules, and the collaboration of faculty and students in interdisciplinary research. (Received September 22, 2009)

1056-Q5-1755 **D. Brian Walton*** (waltondb@jmu.edu), MSC 1911, Roop 110, James Madison University, Harrisonburg, VA 22807, and **Anthony Tongen**, **Nusrat Jahan** and **Reid Harris**. *The Growth of Interdisciplinary Math-Biology Courses at James Madison University.* Preliminary report.

Initiated by a team-taught math-biology modeling course and then amplified by an NSF-UBM grant (NSF-DMS 0734284), James Madison University has seen a significant growth in interdisciplinary courses between the mathematics and biology departments. Team taught courses include the math-biology modeling course, an introduction to biometry, and a biomechanics course. The impacts from these efforts have increased the exposure particularly of biology students to more mathematical content in addition to developing the awareness of mathematics students to biological applications. In addition, new connections between biology and mathematics faculty have increased the interest in the interactions between mathematics and biology generally. Efforts toward a more biological core mathematics course for biology majors will also be discussed. (Received September 22, 2009)

1056-Q5-1777 **Jan Rychtar*** (rychtar@uncg.edu), Department of Mathematics and Statistics, The University of North Carolina at Greensbor, Greensboro, NC 27410. *Research in Mathematical Biology at UNCG.*

"UBM/RUI: Using Collaborative Undergraduate Research to Train Students in Mathematics and Biology at the University of North Carolina at Greensboro" started in 2006 and brought together 6 faculty and 23 undergraduate students of various background. The primary goals of our project are to generate new knowledge at the interface of mathematics and biology and to provide an integrated bio-mathematical research opportunity for undergraduate students at the University of North Carolina at Greensboro (UNCG). We describe how we are engaging students in research, educational, outreach and social activities. We will also present an overview of our results. (Received September 22, 2009)

1056-Q5-1882 **George T Yates*** (gyates@ysu.edu), Department of Mathematics and Statistics, Youngstown State University, One University Plaza, Youngstown, OH 44555. *Mathematical Biology and Undergraduate Research (MBUR) at Youngstown State University.*

A cross disciplinary research program that engages undergraduate students in real research was started at Youngstown State University. The program in Mathematical Biology and Undergraduate Research (MBUR) teamed a biology and mathematics student to conduct genuine research under the mentorship of faculty members in mathematics and in biology. Four such teams were selected and conducted separate research projects over the course of one year. The program used a combination of courses, intensive summer research and sustained involvement to educate and motivate the students. Students presented their findings at local, regional and national meetings. A regional conference in Mathematical Biology was initiated and an interdisciplinary minor in biomathematics was developed. Existing courses were modified and new courses were developed. Student research projects included (1) the role of intracellular calcium on arrhythmias in long QT syndrome, (2) the mechanisms of senktide induced depolarization of pyramidal cells in the prefrontal cortex, (3) selenium metabolism in *Stenotrophomonas maltaphilia*, and (4) modeling of selenite resistance in *Enterobacter sp.* The program was funded by NSF grant DBI-0827205. (Received September 22, 2009)

1056-Q5-1969 **Semen Koksal*** (skoksal@fit.edu), 150 W. Univ. Blvd., Florida Institute of Technology, Dept. of Mathematical Sciences, Melbourne, FL 32901. *UBM Research and Training Activities in BioMath.* Preliminary report.

In this talk, we will present the research and training activities for the undergraduate students in mathematical and biological sciences. We will give examples from the newly established courses and the research projects. We will also discuss the Challenges and rewards of biomathematical undergraduate research and training. (Received September 22, 2009)

1056-Q5-1988 **Angela B. Shiflet*** (shifletab@wofford.edu) and **George W Shiflet** (shifletgw@wofford.edu), Wofford College, 429 N. Church St., Spartanburg, SC 29303. *Modeling the Spread of Disease in Undergraduate Microbiology.*

Most college courses in microbiology, or the study of microorganisms, emphasize the biology of bacteria and viruses, including those that are human pathogens. Introducing students to epidemiology, which considers the causes, dispersal, and control of disease, is a challenging aspect of the course. Disease transmission models have helped develop successful strategies for managing epidemics, but most science students are unaware of their advantages and complexities. To address this challenge, the microbiology course at Wofford College has incorporated a sequence of four laboratories on modeling the spread of disease. After a tutorial on using a system dynamics software tool, students in pairs investigate various diseases, develop models of the spread of those diseases, present their work, and write an analysis of the results. Students in Wofford's Emphasis in Computational Science, who have studied in depth modeling and simulation with application to the sciences, serve as laboratory assistants and mentors. Evidence from test scores and self-assessment support the hypothesis that this sequence of laboratories improved student understanding of human disease dynamics and demonstrated the utility of mathematical models. (Received September 22, 2009)

1056-Q5-2023 **Urmi Ghosh-Dastidar*** (ughosh-dastidar@citytech.cuny.edu), Namm 711 (Mathematics Department), 300 Jay St., Brooklyn, NY 11201. *Bio-Surveillance in Undergraduate Mathematics Classroom.* Preliminary report.

Knowledge of disease outbreaks (exposures and outcomes), and factors affecting disease transmission is the groundwork of epidemiology and public health. In this presentation, the author will demonstrate how undergraduate students can be exposed to the topic of Bio-Surveillance in classroom environment. The students are exposed to analysis of spatial disease data, and illustration of the importance of such techniques in public health, geography and epidemiology. (Received September 22, 2009)

# Using Computer Algebra Systems in the Calculus Sequence

1056-R1-255 **Melvin G. Royer*** (melvin.royer@indwes.edu), Department of Mathematics, Indiana Wesleyan University, 4201 S Washington St, Marion, IN 46953. *Gabriel's Other Equipment.* Preliminary report.

This Calculus II laboratory introduces Gabriel's Horn (infinite surface area but finite volume), then investigates other solids of revolution with similar curious behavior. The overall goal is to have students discover the following facts:

1) A solid with finite surface area must have finite volume but not vice-versa

2) The finitude of the planar area of the generating region and the finitude of the volume of the solid are independent

3) A planar region with finite perimeter must generate a solid with surface of finite area but not vice-versa

Most examples are compiled from journals, though a few seem to be new. One category of solids uses improper integrals while the other involves infinite series. Since many results cannot be expressed with elementary functions and since numerical evaluation is unreliable, students are guided through extensive use of integral and series comparison tests. Other benefits to student learning include exposure to some bounded fractal-like surfaces and to some classical summation results.

The primary uses of the computer algebra system are (1) visualizing the solids, (2) automating the routine calculus involved in setting up the surface and arc length integrands, and (3) evaluating a few of the integrals and summations. (Received August 20, 2009)

1056-R1-317 **Daniel Maxin*** (daniel.maxin@valpo.edu), Department of Mathematics and CS, 1900 Chapel Drive, Valparaiso, IN 46383. *Why do we need intervals for the First Derivative Test?* Preliminary report.

Every condition stated in a theorem has a purpose and students, from time to time, should ask themselves why that particular condition is there and what exactly DOES NOT work if we disregard it. In this presentation I will focus on two familiar theorems in Calculus 1: the First Derivative Test and the Increasing/Decreasing test. One critical feature in these theorems is that the sign of the derivative (positive or negative) is required on an interval and not on an isolated point. From the student perspective, the word "interval" is easily overlooked and, in other cases it is not even mentioned in the statement of the theorem. To illustrate this I will propose a MAPLE exercise that leads to two counter-examples emphasizing the importance of finding the sign of the derivative on intervals rather than isolated points. (Received August 28, 2009)

1056-R1-410 **Andrew J Simoson*** (ajsimoso@king.edu), Andrew Simoson, King College, 1350 King College Road, Bristol, TN 37620. *In search of the big bubble.*

Air bubbles, as they cascade upwards underwater, often tend to collesce into a big bubble, whose upper part is the upper part of a sphere and whose lower part is a plane. Given a very simple model of the dynamics of water pressure—where the bubble's shape is determined by some convex combination of total force on the bubble's surface and the bubble's height for a given volume of air at a particular depth—we try to recreate such a bubble's shape by approximating this convex combination as a single expression involving $n$ profile points at equally spaced depths. By solving the system of $n$ partial derivatives set to zero, we can find the optimal shape of the bubble. Of course, to solve this sytem we use a computer algebra system—which provides a fun and powerful demonstration of solving a max/min problem in a Calculus III context. (Received September 04, 2009)

1056-R1-488 **Robert P. Webber*** (webberrp@longwood.edu), Math and CS Department, Longwood University, 201 High Street, Farmville, VA 23909. *Illustrating Gradients.*

A standard Calculus III problem is: Given a function of two variables, find the direction and magnitude of the maximum change in the dependent variable at a given point.

The solution is to calculate the gradient of the function at the point. The gradient gives the direction, and its magnitude gives the maximum change.

It would be nice to illustrate the solution graphically. This would help give students an intuitive understanding that the gradient really does solve the problem. However, such graphs are infeasible without technology, except in the simplest of cases.

This paper will show, using Maple, how to graph several contour lines, draw the gradient vector at the point, and plot several other vectors from the point showing the rate of change in various directions. Students will observe the magnitudes of the vectors and see that the gradient is the longest.

Finally, a peculiarity of Maple that could produce a misleading graph will be noted. By default, Maple draws the width of a vector to be a function of its length. If we are interested in comparing lengths only, we need to set the widths to be the same. Otherwise, the graph will encourage us to compare in two dimensions instead of one! (Received September 09, 2009)

1056-R1-880 **Leon Brin*** (`brinl1@southernct.edu`), Southern CT State University, Math Department, New Haven, CT 06515. *Related Rates.*

We will discuss how to solve related rates problems with 4 lines of CAS code. An examination of the code will reveal how the act of using the computer to solve such problems illuminates the process almost to the point of trivializing it (thus producing an "aha"). Similarly, we will explore other typical calculus problems which are atypically done with the aid of a computer. (Received September 18, 2009)

1056-R1-1288 **Karl-Dieter Crisman*** (`karl.crisman@gordon.edu`). *Interactive Chaos Mathlets for Calculus I.* Preliminary report.

In a first calculus course, it can be difficult to convey that mathematics is more than a slew of formulas (and perhaps a few proofs). This is particularly true for a course with a broad range of constituencies. Concepts of chaos provide a good way to show that experimentation and surprise are part and parcel of math! However, without a well-defined context, this can be overwhelming or tedious for students.

In this talk, we demonstrate easy-to-use interactive mathlets exploring well-known instances of chaos relating to the concepts of limits, derivatives, and integrals. These are appropriate for guiding labs with reports, or simply as an in-class demonstration. We will demonstrate them using the software Sage; modifying them for recent releases of Mathematica and Maple, or creating one's own, should be straightforward. (Received September 21, 2009)

1056-R1-1382 **William E Fenton*** (`wfenton@bellarmine.edu`), Dept. of Mathematics, Bellarmine University, 2001 Newburg Road, Louisville, KY 40205. *Exploratory Labs in Multivariable Calculus.* Preliminary report.

My department offers Calculus III with a weekly lab period. When I have taught the course, I used these lab times for computer explorations. Over several years, I have developed a collection of lab activities that cover the entire course. Typically student groups do 7-8 short activities in a two hour lab period. Following a constructivist approach, these activities introduce concepts and build an experiential foundation on which to build in the ensuing class periods. The activities are written for Maple but also ask the students to sketch, calculate, and write.

For this presentation, I will demonstrate a small selection of activities. One activity uses numerical computations to explore properties of the dot product. A second activity uses graphs to explore local linearity and contour plots. A third uses computation to investigate Riemann sums in two variables and the double integral. Other activities may be included as time allows. (Received September 21, 2009)

1056-R1-1779 **Paul E. Seeburger*** (`pseeburger@monroecc.edu`), 1000 E. Henrietta Rd., Rochester, NY 14623. *Exploring Velocity and Acceleration Vectors Visually.* Preliminary report.

In multivariable calculus, we ask students to calculate vector-valued functions for velocity and acceleration, given a position function. Students often find it easy to visualize the velocity vector being tangent to the space curve describing the motion, but they rarely have a clear picture of the acceleration vector and its relationship to the motion and to the corresponding velocity. Using a freely available online multivariable calculus applet called CalcPlot3D, students can complete a guided exploration of velocity and acceleration. CalcPlot3D is part of an NSF-funded grant project called Dynamic Visualization Tools for Multivariable Calculus (DUE-CCLI #0736968). See http://web.monroecc.edu/calcNSF/. As part of this guided activity, students complete a pre-test, answer exploration questions, and then complete a post-test. The pre- and post-tests measure what improvement occurs in their conceptual understanding of velocity and acceleration by completing the visual exploration. Student responses to this online activity can be sent to instructors for grading purposes. This exploration is part of a larger collection being developed for this project. (Received September 22, 2009)

# Visualization in Mathematics

1056-R5-252 **Laurene V. Fausett*** (Laurene_Fausett@TAMU-Commerce.edu), Department of Mathematics, Texas A&M University-Commerce, Commerce, TX 75429-3011. *Using Computer Graphics as an Aid to Visualizing Functions of a Complex Variable.*

Many aspects of the study of complex variables can be illustrated using simple Matlab scripts and Mathematic notebooks. The use of simple programs for graphing complex functions, ranging from basic analytic functions to conformal mappings and Schwarz-Christoffel transformations, will be discussed. In addition, several example of the use of plots of the modulus of f(z) will be given. These help students see what it means for a function to satisfy the conditions needed for using complex contour integration to find improper integrals on the real line. All of the programs discussed allow the user to experiment with changing parameter values, which improves visualization of the functions being studied. (Received August 19, 2009)

1056-R5-290 **Marshall Hampton*** (mhampton@d.umn.edu), 1117 University Dr., Dept. of Mathematics and Statistics, UMD, SCC 140, Duluth, MN 55812. *Visualizing the polyhedral geometry of algebraic systems.*

This talk will highlight the connections between the geometry of polytopes and the solutions to polynomial systems of equations. Beginning with the Newton polytope of a single polynomial, we will explore other objects and operations such as the Minkowski sum, Bernstein's theorem, amoebae, and Groebner fans. The visualizations shown will all be done with free and open-source software, primarily Sage, Singular, Gfan, cddlib, and ffmpeg. (Received August 25, 2009)

1056-R5-362 **Deane E. Arganbright*** (darganbright@dwu.ac.pg), Dept. of Mathematics and Computing Science, P.O. Box 483, Divine Word University, Madang, Papua New Guinea. *Visualization via Excel in Mentoring Mathematics Faculty of a Developing Nation.*

The author is a professor at Divine Word University in Papua New Guinea, a young university in a developing nation, providing assistance in the start-up of its new mathematics department. Because the country has a shortage of mathematicians with advanced mathematics degrees, it is essential to enhance the mathematical backgrounds of the junior-level academic staff, many of whom often possess only a first degree with limited theoretical content. The enhancement includes developing instructional skills that teachers need in order to be effective tutors in courses such as calculus, linear algebra, and statistics, as well as helping them to increase their backgrounds in theory. This material studied includes topics from the upper undergraduate level. The program is carried out by senior academic staff members who serve as mentors for the younger staff. This presentation describes and illustrates a novel way of using a spreadsheet to create effective visualizations of many theoretical aspects of calculus that in turn provide a way to develop insights into definitions, theorems, and proofs. In the process, the younger teachers also acquire experience in using a tool that they can employ for creating their own useful classroom visualization demonstrations. (Received September 02, 2009)

1056-R5-657 **Joyati Debnath*** (jdebnath@winona.edu), Winona State University, Department of Mathematics and Statistics, 304 Gildemeister Hall, Winona, MN 55987, **Srabasti Dutta** (SDutta@cse.edu), College of Saint Elizabeth, Depart of Mathematics and Computer Science, and **Andrew Jones** (andrew.jones@famu.edu). *Visualization for the Simulation of the Chemical Vapor and Infiltration Process.*

Reactive fluid flow is important for studies of chemical vapor, infiltration, diesel, particulate filter and detection of hazardous gases. In systems where there are large number of resulting species simulations and optimizations becomes difficult, if not impossible. In this presentation we will attempt to classify sets of chemical species by reaction rates and diffusion rates thus creating a set of equivalent classes that are much smaller in numbers than individual elements. We will create a reduced reaction set that will simulate the entire gas reactive flow to reduce computing time. To achieve this, we will employ temporal and spatial visualization techniques to identify aggregates of chemical species with similar properties. (Received September 15, 2009)

1056-R5-1064 **David Booth*** (sdbooth@sbcglobal.net), 1701 Kenwood Ave, Austin, TX 78704. *Educational Applications of Projective Geometry.* Preliminary report.

Projective geometry was thought to have educational potential in the early twentieth century but was lost in curricular evolution. Various educational experiments have been carried out in recent years to reintroduce it. They begin with descriptive geometry. Projectivities seem natural after considering stereoscopic images. Cross ratios give a connection to trigonometry and computational topics. The introduction of graphical statics in physics lessons supports physics and geometry alike. There have been some Moore method lessons with select high school students involving geometric algebra connected with moments, bivectors, and related topics that resemble applied projective geometry. (Received September 20, 2009)

1056-R5-1090 **Martin Levin*** (mdlevin_public@msn.com), 604 Winona Ct., Silver Spring, MD 20902. *Projective Geometry as a Vehicle for Schooling the Imagination.*

The ability to form geometric images in one's mind, to hold them, and to set them in movement is a skill that is often unnoticed, but which is crucial for mathematical thinking. This skill can be trained. It is best developed not by just showing pictures, but by always asking the listener to imagine more than what you've shown them so far. The students become raptly engaged. This talk will use projective geometry as an example of how this can be done. The subject lends itself particularly well to this purpose, especially if the students are asked to make a lot of drawings. One makes a drawing and then watches it transform as certain points move off to the infinite and return on the other side. (Received September 20, 2009)

1056-R5-1256 **Terri L. Bennett*** (bennettt1@southernct.edu), Southern CT State University, Department of Mathematics, 501 Crescent Street, New Haven, CT 06515. *Spatial Visualization: Is There a Gender Difference?*

The questions of whether gender differences in spatial skills exist and if so, whether these differences affect the performance of women in mathematics classes that require spatial visualization have been the focus of many research studies over the past twenty years. As a result, theories ranging from biological factors to culturally based differences in the sexes to performance factors related to testing environments have been proposed and tested. Performance factors include time limits on tests, test taking strategy, previous task experience, and expectations of task success. A summary of some of the gender differences that have been found in the research, the theories that have been proposed, and ways in which the researchers were able to decrease the gender gap by changing the performance factors will be presented. In particular, studies that examined gender differences on the Mental Rotations Test (MRT), which has produced the largest gender gap on record, will be addressed. (Received September 21, 2009)

1056-R5-1268 **Ami Mamolo*** (amamolo@yorku.ca), Mathematics and Statistics, York University, 4100 Keele Street, Toronto, Ontario M3J 1P3, and **Walter Whiteley** (whiteley@mathstat.yorku.ca), Mathematics and Statistics, York University, 4700 Keele Street, Toronto, Ontario M3J 1P3. *Visualizing the Popcorn Box.*

We describe a visual and manipulative approach, with concrete materials, to a classical 'optimization' problem: "The Popcorn Box Problem".

Our visual-kinaesthetic approach to finding the (popcorn) box of maximum volume allows students to: (i) develop geometric reasoning for the rate of change of volume; (ii) develop geometric reasoning for where the optimum must be, and why; (iii) visualize geometric optimization and rates of change in a way that precedes, and complements, the work with formulae and calculus techniques.

Our approach to the Popcorn Box Problem highlights 'big ideas' which are hidden in the usual calculations, but which can be recognized when the student looks back with fresh eyes. We propose this as a valuable engagement for high school students, pre-calculus and calculus students, as well as prospective and practicing Mathematics teachers. (Received September 22, 2009)

1056-R5-1482 **John W Hoggard*** (jhoggard@edinboro.edu), Dept. of Mathematics and Computer Science, 200 Doucette Hall, 215 Meadville St, Edinboro, PA 16444. *Drawing by hand and machine: Visualizing solids of revolution.*

Calculus students have difficulty finding volumes of solids of revolution. We as teachers encourage students to draw the solids as an aid to visualization, but many students seem to lack the necessary drawing skills. How can we teach three-dimensional visualization? I will discuss three ways in which I have come to teach my students to draw (and visualize) solids of revolution in calculus: First, by a simplified direct drawing lesson; second, by physical models; and third, by computer animations and interactive web displays generated using the software *Mathematica*. The interplay of all three methods helps students learn to sketch (and visualize) the solids for themselves. (Received September 21, 2009)

1056-R5-1562 **Lily Moshe** (lilychka@mathstat.yorku.ca), Mathematics and Statistics, York University, 4700 Keele Street, Toronto, Ontario M3J 1P3, Canada, **Margaret Sinclair** (MSinclair@edu.yorku.ca), Faculty of Education, York University, 4700 Keele Street, Toronto, Ontario M3J 1P3, Canada, and **Walter Whiteley*** (whiteley@mathstat.yorku.ca), Mathematics and Statistics, York University, 4700 Keele Street, Toronto, Ontario M3J 1P3, Canada. *Spatial Visualization for Pre-Service Teachers.*

We present some materials and observations from an ongoing study of activities to strengthen the spatial visual reasoning of in-service and pre-service teachers of mathematics. The activities focused on connections between 2-D and 3-D, with related explorations on reflection and rotational symmetry in both, and on passing between dimensions, such as projections and sections of 3-D into 2-D. One of the innovative activities combined filling of (inverted) pyramids with exploration of dilations through dynamic geometry to investigate similarity transformations.

The teachers encountered some obstacles to effectively reasoning with the concrete materials, and communicating their observations - obstacles that other students at University and College are likely to experience. We describe a few of those obstacles. The team of researchers found that we were faced by some of the same difficulties and that we had to develop a shared discourse for the geometry, the reasoning and our communications. This led us to recognize the lack of a larger shared trajectory in development of spatial representations, reasoning and communication in our larger curricula. (Received September 22, 2009)

1056-R5-1589 **Martin Levin*** (mdlevin_public@msn.com), 604 Winona Ct., Silver Spring, MD 20902. *Projective Geometry as a Vehicle for Schooling the Imagination II.*

Participants will make drawings that illustrate the presentation made in part I. (Received September 22, 2009)

1056-R5-1614 **Talitha M Washington*** (tw65@evansville.edu), Department of Mathematics, University of Evansville, 1800 Lincoln Ave, Evansville, IN 47714. *Confluent Graphs: Making Graphs Pretty.*

This presentation explores visualizations of graphs. In particular, we will discuss confluent graphs, i.e., graphs that can be represented by vertices and smooth curves such that two vertices are adjacent if there is a smooth edge between then with non-transversal intersections. We will also discuss how to incorporate this topic into classroom instruction. This is work that was done during the summer of 2009 at DIMACS as part of the Reconnect Conference. (Received September 22, 2009)

1056-R5-1812 **Nathan Carter*** (ncarter@bentley.edu), 175 Forest St., Waltham, MA 02452. *Visualization Lessons from* Visual Group Theory.

I will introduce the value of visualization in group theory using specific examples from the book *Visual Group Theory* and the complementary free software package *Group Explorer*. (*Visual Group Theory* introduces the subject from a thoroughly visual perspective, making concepts of symmetry clear using Cayley diagrams.) These projects will then be viewed as case study from which we can learn lessons about (1) specific learning benefits of mathematical visualization in general and (2) the importance of technology in the creation of mathematical visualizations. (Received September 22, 2009)

1056-R5-1978 **Charles Andrew Tannouri*** (ctanno1@students.towson.edu), Baltimore, MD. *Efficient Graph Visualization for Applications: Databases, Data Mining, and Video Games.*

A graph is a visual representation of data characterized by a set of nodes connected by a certain number of edges. Graphs appear in a wide range of mathematical problems, and are used as an indispensable problem-solving tool in computer science and other fields. However, the complex and often convoluted nature of these data sets makes them very difficult to illustrate clearly and efficiently in a visually aesthetic form. Simplification of the visualization of such graphs yields the benefit of more friendly access, more efficient use, and easier analysis. Such graphs can be used in software such as those of data analysis tools, video games, or other programs that present cluttered and complex data. By applying graph transformations that take advantage of properties such as confluence, a graph can be represented in a more manageable form. Visualizing such a graph using a three-dimensional interface and rendering the edges using splines to better exhibit the graph's confluence can organize the data of the graph in such a way to simplify its use as a tool to aid in data mining and other graph-centric applications. Configurations of these splines are studied to determine the how effectively a graph can be visually simplified. (Received September 22, 2009)

1056-R5-2001 **Sarah L Mabrouk*** (smabrouk@framingham.edu), Framingham State College, 100 State Street, P.O. Box 9101, Framingham, MA 01701-9101. *Picture This: Making Connections in 3-Space.*

Making the transition from the xy-plane to 3-space is a challenge for students. Despite their living in 3-space, students have difficulty making connections between the equations/functions that they study and the world in which they live. To help them to transition to mathematics in 3-space and to facilitate their understanding the equations/functions that they examine, it is helpful to relate these to objects with which they are familiar. Considering known objects in 3-space, assigning coordinate systems, considering objects in planes, and then creating appropriate equations as well as breaking down equations/functions in 3-space in similar ways helps students to make connections between the equations/functions in 3-space and known three-dimensional surfaces and objects. To visualize mathematics, one needs to understand and relate to equations/functions: to understand and relate to equations/functions they must be put into personal context. While using a CAS helps students to explore new equations/functions, matching these to objects in the real world helps them to understand and to relate to their study of mathematics in 3-space. In this presentation, I will discuss the use of Maple and digital cameras to help students to make sense of the mathematics in 3-space. (Received September 22, 2009)

1056-R5-2027 **James D. Factor** and **Edmond J. Nadler*** (enadler@emich.edu), Mathematics Department, Eastern Michigan University, Ypsilanti, MI 48197. *Visual Analytics to Explore Elementary Probability.* Preliminary report.

We present an educational module that explores the use of Visual Analytics to as a tool for undergraduates to learn basic concepts in probability. Visual Analytics is an emerging field that combines computer visualization tools with algorithms and human interaction to solve problems. Applying visualization tools to real data, using techniques such as parallel coordinates, will enable students to get a hands-on feel for basic concepts in probability, such as independence of events. The module was initiated at the Reconnect 2009 summer workshop "Visual Analytics and Applications" held at Rutgers University. (Received September 22, 2009)

1056-R5-2045 **Rae Young Kim*** (kimrae@msu.edu), 118J Erickson Hall, East Lansing, MI 48824, and **Sharon Senk** (senk@msu.edu), D320 Wells Hall, East Lansing, MI 48824. *Pedagogical Understanding of Non-Textual Elements in Mathematics Textbooks among Teachers and Curriculum Developers.* Preliminary report.

Many studies have explored mathematics textbooks as a crucial medium in teaching and learning to understand students' learning opportunities and achievement gap across countries. However, little attention has been given to the roles of non-textual elements (e.g., pictures, illustrations, graphs, and mathematical figures) in mathematics textbooks: what do non-textual elements offer for teaching and learning mathematics, what aspects of non-textual elements are helpful for, or detrimental to, student learning, and how do they differ across different educational systems? As a comparative investigation, this study analyzed qualitative interview data from 21 secondary mathematics teachers and 7 curriculum developers in South Korea and the United States in order to find commonalities and differences in important aspects of non-textual elements in mathematics textbooks. The results provide useful information about what aspects of non-textual elements teachers and curriculum developers considered important for student learning as well as practical implications on how to improve non-textual elements in mathematics textbooks. (Received September 22, 2009)

1056-R5-2072 **Nissa Yestness*** (Nissa.Yestness@unco.edu). *Diagrams in Abstract Algebra: How are Diagrams used in the Proving Process?* Preliminary report.

Research on visual representations and diagrams in K-12 mathematics includes investigations from arithmetic (Agathangelou, Papakosta, & Gagatsis, 2008) to high school calculus (Zubieta & Meza, 2008) including fractions (Deliyianni, Elia, Panaoura, & Gagatsis, 2008), word problems (Uesaka & Manalo, 2006), algebra (Hitt, Gonzalez-Martin, & Morasse, 2008), and geometry (Chen & Herbst, 2007). Research on diagram use by students in collegiate mathematics is less abundant, specifically in abstract algebra. A literature review of abstract algebra and diagrams yielded only two articles (Almeida, 1999; Zazkis, Dubinsky, & Dautermann, 1996). In Gibson's (1998) study of 12 undergraduates in a beginning proof course, one of his research questions was, "In what ways do students use diagrams while proving?" (p. 286). Building on Gibson's work, I ask, what is the nature of undergraduate students' use of diagrams in understanding and constructing proofs related to groups, subgroups, and isomorphisms? I will address this question by investigating ways Gibson's descriptions about students' use of diagrams in proof writing in analysis are similar for students in abstract algebra. Can these student uses of diagrams be further detailed? Are there additional student uses of diagrams? (Received September 23, 2009)

# Wavelets in Undergraduate Education

1056-S1-231 **Janine Wittwer*** (jwittwer@westminstercollege.edu), 1840 S 1300 E, Salt Lake City, UT 84105. *Teaching a Wavelets course in May term.*

This year I taught a course on discrete Wavelets following Patrick Van Fleet's Discrete Wavelet Transformations: An Elementary Approach with Applications during May Term, a one month semester. Because of the brevity of the term, I had to be selective in the topics I covered. I will discuss what worked (and didn't work) in this class as well as student reactions, projects and plans for this class in the future. (Received August 17, 2009)

1056-S1-528 **Edward Aboufadel***, Department of Mathematics, A-2-178 MAK, GVSU, Allendale, MI 49401, and **Robert Castellano** and **Derek Olson**. *A Wavelet-Based Unsupervised Learning Algorithm to Cluster Diabetics Based on Continuous Glucose Monitoring Data.* Preliminary report.

Type 1 diabetes is a serious disease, and it is estimated that at least one million Americans are afflicted. The main challenge that diabetics face is regulating their blood glucose levels. Prior research suggests that reducing variability of blood glucose is a key component of this regulation. This presentation will describe a new measurement developed to quantify the variability or predictability of blood glucose. Using continuous glucose monitors (CGMs), this measurement – called a PLA index – can be a new tool to classify diabetics based on their blood glucose behavior and may become a new method in the management of diabetes. The PLA index was discovered while taking a wavelet-based approach to study the CGM data. We will discuss how the PLA index and the wavelet analysis are connected and how this leads to the PLA index's potential utility. This work was done at the 2009 Grand Valley State University Research Experience for Undergraduates program. (Received September 11, 2009)

1056-S1-1263 **Jill E. Guerra*** (jguerra@uafortsmith.edu), University of Arkansas - Fort Smith, 5210 Grand Avenue, Fort Smith, AR 72913, and **John C. Merkel, III**, **Eric A. Bickerton** and **Warren Chancellor**. *Authentication Using Wavelets, part I.*

In this talk we will discuss a procedure for using wavelets and statistical analysis for art authentication purposes. Applications to forgery and fingerprints will be discussed in part II of this presentation. (Received September 21, 2009)

1056-S1-1270 **John C. Merkel, III*** (john.merkel@gmail.com), **Jill E. Guerra**, **Warren Chancellor** and **Eric A. Bickerton**. *Authentication Using Wavelets, part II.*

This talk reports on undergraduate research conducted during Fall, 2009. Following the program outlined in part I of this presentation, we use wavelets to authenticate fingerprints and signatures. (Received September 21, 2009)

1056-S1-1334 **Phil Gustafson*** (pgustafs@mesastate.edu), Mathematics Department, Mesa State College, 1100 North Ave, Grand Junction, CO 81501-3122. *Portable Haar Wavelet Projects with MATLAB.* Preliminary report.

Haar wavelet projects are suitable for use in a variety of undergraduate mathematics courses, and serve as a great way to introduce students to an interesting and current application of mathematics. The relative simplicity of discrete Haar wavelets make them accessible to students with only a basic familiarity of matrix algebra. Using microphones and digital cameras, student-generated audio and image files can readily be processed with MATLAB programs to illustrate concepts such as signal thresholding and compression. This talk will highlight the use of Haar wavelet projects in an undergraduate topics course on Fourier analysis. These projects are designed to illustrate the importance of different expansions in the representations of functions and signals, and to bring students closer to modern applications of mathematics in our digital world. These projects can be readily adapted for use in courses such as calculus, linear algebra, and mathematical modeling, as well as serving as a starting point for senior research experiences. (Received September 21, 2009)

1056-S1-1479 **John A Rock*** (jrock@csustan.edu), Mathematics Department, One University Circle, Turlock, CA 95382, and **David Ruch** (ruch@mscd.edu), **Kenneth Hoover** (khoover@csustan.edu), **Helmut Knaust** (hknaust@utep.edu) and **Roger Zarnowski** (roger.zarnowski@angelo.edu). *A Module for the Construction of Scaling Functions using the Cascade Algorithm.*

Solving a dilation equation is fundamental in wavelet theory and applications, for the scaling function solution leads to wavelets. There is usually no closed-form solution to dilation equations, and the iterative cascade algorithm must be implemented to obtain good approximations to the scaling function. In this talk we discuss developing a student project exploring these issues.

While it is easy to write a module that implements the cascade algorithm using piecewise defined functions in the continuous setting, such a module proves to be remarkably slow for even a handful of iterations. In this talk, a module implementing the cascade algorithm in a much more efficient vector-form version will be developed and suggestions for how to get students to develop their own modules will be discussed. (Received September 21, 2009)

1056-S1-1535 **Patrick J Van Fleet*** (pjvanfleet@stthomas.edu), 2115 Summit Avenue #OSS201, Department of Mathematics, University of St. Thomas, St. Paul, MN 55105. *Fourier Series and the Discrete Wavelet Transformation.* Preliminary report.

Fourier series are commonly used by students in physics and engineering courses. In mathematics, students might see them in a differential equations or possibly in an analysis course, but rarely elsewhere in the undergraduate curriculum. Mastery of the elementary ideas of Fourier series can be invaluable for undergraduate students – they can learn about convergence in norm or solving problems in the "transform domain." Unfortunately, unless mathematics students take a course in physics or engineering, they usually do not see how Fourier series can be employed in a wide variety of applications. Fourier series play a prominent role in the development of the discrete wavelet transformation and we have found that an undergraduate course on discrete wavelet transformations and their applications provides a nice setting for the introduction of Fourier series and their important role in filter design and signal/image processing. In this talk, we will outline how Fourier series are used to construct discrete wavelet transformations and illustrate the benefits of a concentrated study of this important mathematical tool. (Received September 22, 2009)

1056-S1-1691 **Cristen M Bonz** (cmbonz@stthomas.edu), University of St Thomas, Mail 806, 2115 Summit Ave, Saint Paul, MN 55105, and **Elizabeth A Motz*** (eamotz@stthomas.edu), University of St Thomas, Mail 296, 2115 Summit Ave, Saint Paul, MN 55105. *Wavelet Packets and Image Compression.* Preliminary report.

In order to store and image, each pixel of the image uses 8 bits of storage space. Image compression allows for the amount of storage space needed per pixel to be decreased. In this project, ideas from the FBI Fingerprint Compression method will be used to construct an image compression routine for a set of homogeneous images. The basic algorithm for image compression begins with normalization of the image. Next, the image is transformed and quantized. Finally, the image is encoded. In this talk we will describe the role the Wavelet Packet Transform plays in the algorithm and illustrate the method with several examples. (Received September 22, 2009)

1056-S1-1784 **William David Hall*** (whall@csustan.edu), c/o Dr. Kenneth R. Hoover, Department of Mathematics - CSU Stanislaus, One Univeristy Circle, Turlock, CA 95382, and **Jonathan Brown**. *A Sufficient Condition for the Optimality of Huffman Encoding.* Preliminary report.

Huffman encoding, developed by David Huffman in 1952, is a very useful tool for lowering the number of bits per pixel (bpp) needed to store an image. It is often applied to images after the discrete wavelet transform. In 1948, Claude Shannon showed that the number of bpp needed to store an image using a lossless compression scheme has a lower bound called the entropy of the image. A natural question is when will Huffman encoding be optimal? In other words, when will the number of bpp needed to store an image after Huffman encoding equal the entropy of the image? In this talk, we present a sufficient condition for this to occur. If the relative frequencies of the values of the pixels follow a certain increasing sequence, then the bpp needed to store the image after Huffman encoding will equal the entropy of the image. (Received September 22, 2009)

1056-S1-1998 **Beth M. Campbell Hetrick*** (bcampbel@gettysburg.edu), Gettysburg College, Department of Mathematics, 300 N. Washington Street, Gettysburg, PA 17325. *Teaching a Wavelets Course at a Liberal Arts College.*

In Fall 2009, the Mathematics Department at Gettysburg College offered a Special Topics course on wavelets and their applications, with a linear algebra course as a prerequisite. We will discuss this course, including its use of Mathematica and the student projects completed at the end of the semester. We will also mention one student's further exploration of wavelets in her senior capstone project. (Received September 22, 2009)

# General Session

1056-Z1-25 **Gizem Karaali*** (gizem.karaali@pomona.edu), Department of Mathematics, Pomona College, 610 N. College Avenue, Claremont, CA 91711. *A Taxonomic Analysis of Standard Calculus Tasks: Bloom in Calculus Education.* Preliminary report.

In education theory, Bloom's taxonomy (1956) is a well-known paradigm to describe and classify domains of learning and levels of cognitive competency. A simple overview of these levels allows one to see that in most introductory (and even upper division) mathematics courses, the standard exercises given to students in homework sets and in examinations are typically limited to lower levels of this categorization. In this note we propose a framework to assess mathematics test problems and their place within Bloom's taxonomy. Using this framework we present a taxonomic investigation of the exercises from several chapters of a mainstream calculus text and show that most of them do not address Bloom's higher levels. (Received August 16, 2009)

1056-Z1-39 **Linda Furuto*** (lfuruto@hawaii.edu), 96-129 Ala Ike, C104E, Pear City, HI 96782. *Bridging Policy and Practice Through Ethnomathematics in the Pacific.*

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 double-hulled Hawaiian 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 non-instrument wayfinding techniques that include celestial 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 2012. It is a vehicle to explore real-world applications of mathematics in global communities, and represents resourcefulness, inventiveness, wisdom grounded in the past, and hope for the future. (Received July 07, 2009)

1056-Z1-52 **Joan E Hart*** (hartj@uwosh.edu), University of Wisconsin Oshkosh, Mathematics Department, 800 Algoma Boulevard, Oshkosh, WI 54901-8631, and **Kenneth Kunen**. *Arcs in the plane.*

Every Cantor set E in the plane is contained in an arc. But the arc need not be smooth or have finite length. Must every Cantor set E at least *meet* a "nice" arc in an uncountable set? Yes, if "nice" means the arc is the image of a path g with $g'$ nowhere 0 and continuous (that is, the arc is $C^1$). No, if "nice" also means $g''$ is continuous (so, the arc is $C^2$). This talk looks at recent results that use derivatives, Taylor's Theorem, and other ideas from calculus and elementary analysis to show there is a Cantor set E that meets each $C^2$ arc in a finite set. For arbitrary uncountable E, the results are independent of the usual axioms of set theory. For these more general E, some results are old, but we note recent partial results for $C^1$ arcs, as well as "nice" questions that remain open. (Received July 16, 2009)

1056-Z1-55 **Robert E Burks*** (reburks@nps.edu), 1411 Cunnungham Rd, GL-220A, Monterey, CA 93943. *Survivor Math: Using Pop Culture to Enhance Learning Mathematics.*

Traditional Student success in undergraduate level mathematics, science, and engineering (MSE) courses depends on a firm understanding of pre-calculus material. Instructors at the United States Military Academy have identified a set of fundamental pre-calculus concepts that all students must possess in order to effectively understand the concepts presented in the school's core academic program. However, every year approximately 5 percent of the freshmen enter under-prepared for success in the school's MSE sequence. I will discuss a modification of the popular television game show, Survivor, as conducted in an undergraduate first semester developmental mathematics course. The focal point of this classroom application is a group-based competitive drill and practice activity designed to increase conceptual understanding in preparation for a fundamental concepts exam. This application takes advantage of available technology to boost instruction creativity and student interest in the classroom. The results of this activity include: increased understanding of the fundamental concepts, increased confidence for the fundamental concepts exam, and increased preparedness for the mathematics concepts presented in future MSE courses. (Received July 17, 2009)

1056-Z1-80 **Santanu Chakraborty*** (schakraborty@utpa.edu), Department of Mathematics, University of Texas - Pan American, 1201 West University Drive, Edinburg, TX 78539. *A Basic College Level Mathematics course for a lay man knowing only four basic operations with nonnegative integers.*

This talk is intended to describe a future course in Mathematics. The target students for this four-credit hour course are the Liberal Arts students for whom some basic knowledge of mathematics is just good enough. The course will cover most of the topics in Elementary, Intermediate and College Algebra and Pre-calculus - namely, nonnegative integers, fractions, decimals, percentages, basic geometry, integers, rational and real numbers, basic algebra, exponents, polynomials, linear, quadratic and polynomial equations and inequalities, their graphs, matrices, conic sections, functions, logarithmic, exponential and trigonometric functions, sequences and series, mathematical induction, counting techniques and some basic probability and statistics. The aim is to make the students familiar with as many important mathematical topics as possible without going in to much depth. The speaker has a lesson plan to be presented in the talk that accomodates all these topics. The course will only include the simplest possible exercises in each and every topic. The distant aim is to make it a core course so that the Liberal Arts students do not have to go through the painful rounds of remedial non-credit courses. (Received July 22, 2009)

1056-Z1-86 **Morteza Shafii-Mousavi*** (mshafii@iusb.edu), Mathematical Science, Indiana University South Bend, PO Box 7111, South Bend, IN 46634-7111, and **Kochanowski Paul** (pkochano@iusb.ed), School of Business & Economics, Indiana University South Bend, PO Box 7111, South Bend, IN 46634-7111. *The Use of Spreadsheets to Illustrate Statistical and Mathematical Concepts.*

In the Indiana University system, as well as many other schools, finite math is a prerequisite for most majors. Statisticians Moore, Peck, and Rossman articulate a set of goals for math prerequisites: including instilling an appreciation of the power of technology and developing skills necessary to use appropriate technology to solve problems, developing understanding, and exploring concepts. The paper describes the use of Excel spreadsheets in the teaching and learning of finite math concepts in the linked courses Mathematics in Action: Social and Industrial Problems and Introduction to Computing taught for business, liberal arts, science, nursing, and education students. The goal is to encourage an appreciation of math and promote writing as students see an immediate use for it in completing actual real-world projects. We emphasize learning and writing about math and the practice of computer technology applications through completion of actual industrial group projects. Through demonstration of concepts using Excel, we stress synergies between math, technology, and real-world applications. These emphasize the learning goals such as quantitative skill development, analytical and critical thinking, information technology, creative reasoning, and writing across the curriculum. (Received July 24, 2009)

1056-Z1-102 **Neil Nicholson*** (nicholsonn@william.jewell.edu), Department of Physics and Mathematics, 500 College Hill, Box 1107, Liberty, MO 64068. *Chess, Church, and Knots: Statistics Through Service and Research.*

A one-semester non-major statistics course typically does not cover non-parametric tests, those usually most applicable to student research projects, and many times, mathematics majors are hardly exposed to statistical work. I will discuss three methods I have used to teach these advanced methods to both mathematics and non-mathematics majors, utilizing service learning and mathematics research. (Received July 27, 2009)

1056-Z1-127 **Radoslav M. Dimitric*** (rdimitric@juno.com), Pittsburgh, PA 15230. *MIHAILO PETROVIC AND HIS INTERVAL MATHEMATICS.* Preliminary report.

In this paper I will examine work of Mihailo (Michael) Petrovic in the area of the so-called interval mathematics. This work is not well known the least because it is mainly written in Serbian and dates at least as far back as 1932. The basic idea is that quantities like real numbers are not known as precise decimal expansions (say for irrational numbers), but we can consider an interval where such a number resides, as a certainty or precise locator. Petrovic constructs this interval mathematics and shows how to perform any operations with such intervals, from the simple kind to the infinitesimal and integral kind. This work is not only important from historical point of view, but it is a distant but significant predecessor of many computational aspects used today, including the so-called fuzzy mathematics. Petrovic cannot be omitted from the small set of significant contributors in these areas. How many of his constructions are useful, but still unused today remains to be scrutinized in more detail. Translation into English of Petrovic' related work on interval mathematics is in preparation and will be available from www.helios-scholar.com (Received July 28, 2009)

1056-Z1-182 **Sarah J Greenwald*** (greenwaldsj@appstate.edu), 121 Bodenheimer Drive, 326 Walker Hall, MATH, ASU, Boone, NC 28608, and **Eric Marland**, 121 Bodenheimer Drive, 324 Walker Hall, MATH, ASU, Boone, NC 28608. *Teaching a Senior Seminar in Humanistic Mathematics.*

Appalachian State University recently instituted a senior capstone requirement. The Appalachian capstone may take the form of a thesis, a class, an internship, student teaching, or other experiences. We class tested a one-hour course that was organized around a series of intertwined themes designed to investigate the interface of mathematics with society, science, and everyday life. In this talk we will report on the course setup, the reactions of the students, and the benefits and challenges of teaching a seminar in humanistic mathematics. (Received August 12, 2009)

1056-Z1-239 **Faun C. C. Doherty** (fdoherty@washjeff.edu), **Christian J. Miedel*** (miedelcj@washjeff.edu), **Peter A. Gentile** and **Jennifer M. Magee**. *A vertex ordering result for an application of DNA sequencing using tripartite unit probe interval graphs.*

Graph Theory has been proven a useful tool in the Physical Mapping problem which is to reconstruct the relative position of DNA fragments along the genome from pair wise overlap information. Some cloning techniques generate clones that are approximately the same length, and their overlap information can be modeled using unit probe interval graphs. A graph is a probe interval graph if its vertices can be partitioned into two sets, probes and nonprobes, with an interval assigned to each vertex so that vertices are adjacent if and only if their corresponding intervals intersect and at least one of the vertices is a probe. A unit probe interval graph has intervals of the same length. If one assumes that we start with a contiguous piece of DNA, then we can assume a canonical order exists on the vertices reflecting the real order of fragments. We investigate the situation in which we have three restriction enzymes cutting DNA into fragments of approximately the same size. We prove that with the exception of vertices occurring at the ends of the interval model, our resulting tripartite unit probe interval graph has a realizable consecutive ordering of the vertices if and only if it is connected, which would provide the ordering of the DNA fragments. (Received September 14, 2009)

1056-Z1-240 **Faun C. C. Doherty** (fdoherty@washjeff.edu), **Peter A. Gentile*** (gentilepa@washjeff.edu), **Jennifer M. Magee** and **Christian J. Miedel**. *The Spaghetti Model: DNA Sequencing using Graph Theory.*

Graph theory is used to model a specific application of the Physical Mapping problem, which is to reconstruct the relative position of DNA fragments along the genome from pair wise overlap information. We call the model that we address in this talk the spaghetti model. A DNA strand is copied many times and cut into pieces of varying length using either an enzyme or a cleaving process, much like cracking handfuls of identical hard pieces of spaghetti. The pieces are then separated by length, and similar sized pieces are collected. Graph theory is used to order this collection of fragments. This problem can be mathematically modeled using a graph called a unit interval graph. An interval graph G is a graph whose vertices can be assigned to intervals on the real line such that two vertices are adjacent in G whenever their corresponding intervals overlap. A unit interval graph is an interval graph in which the intervals are of equal length. We prove that given a unit interval graph that models the overlap data, one can successfully order the pieces of the DNA sequence, and we give an algorithm to that effect. We also provide an algorithm which produces a minimum set of intervals necessary to order the entire DNA sequence. (Received September 14, 2009)

1056-Z1-260 **Laurene V Fausett*** (Laurene_Fausett@TAMU-Commerce.edu), Texas A&M University-Commerce, Department of Mathematics, Commerce, TX 75429-3011. *Using Neural Networks for Near-Interpolation of Scattered Data.*

Although it has been known theoretically for some time that neural networks are capable of approximating arbitrary input-output mappings to arbitrary accuracy, these results are based on the network having "enough" hidden units, "enough" training data, and "enough" training. In this talk we show that it is in fact practical to use either of two standard neural networks for near-interpolation of small to moderate sized data sets, with input from $R^2$ and output in $R$. Examples illustrate the typical behavior of these networks, and the contrasts between neural and numerical approaches. Several small but important modifications to these networks are presented which improve network results. The characteristics of neural network solutions which may be desirable in certain settings are also discussed. (Received August 21, 2009)

1056-Z1-288 **Greisy Winicki Landman*** (greisyw@csupomona.edu), 3801 W. Temple Ave., Pomona, CA 91768. *One of the first mathematical texts of the Jewish Bookcase.*

Yesode ha-tebunak u-migdal ha-emunah, usually referred to as "The Encyclopedia" was written by the Spanish Jewish scholar Abraham Bar Hiyya Ha-Nasi in the twelfth century. It is one of the first mathematical books written in Hebrew. It may not present original results but its uniqueness is in the integration of Muslim, Greek and Babylonian mathematical knowledge and the development of scientific terminology in Hebrew, a language that was then maintained mainly for religious purposes. In this session, some of the problems and approaches presented by Bar Hiyya will be discussed. (Received August 25, 2009)

1056-Z1-294 **Heidi A. Haynal*** (heidi.haynal@wallawalla.edu), 204 South College Avenue, College Place, WA 99324. *What a higher q-skew τ-derivation can do for you.*

There's more than one way to twist the multiplication in a polynomial ring. When automorphisms alone are used, we know necessary and sufficient conditions for the new ring to satisfy a polynomial identity. When automorphisms with derivations are used, it seems unlikely that the resulting noncommutative ring would ever satisfy a polynomial identity. However, under certain restrictions, the polynomial identity degree of such a ring has been pinned down by comparing it with its associated skew polynomial ring without derivations. We'll show how the presence of a higher $q$-skew $\tau$-derivation allows us to extend previous results to a larger class of skew polynomial rings. (Received August 26, 2009)

1056-Z1-315 **Linda McGuire*** (lmcguire@muhlenberg.edu), Department of Mathematics and, Computer Science, Allentown, PA 18104. *Proving in the Right Circles.*

This talk will address the use of what this presenter calls "Proof Circles" as an approach to helping students acquire, develop and deepen critical reading, proof writing and problem-solving skills. Proof Circles are group work structures (similar to literary circles) with a decidedly mathematical focus and format.

In a Proof Circle, students are organized into working groups and each person is assigned a specific role. A group is given a problem to solve and a detailed argument justifying their result is required. Each individual student then assumes their role and approaches the problem from the perspective that their assigned part dictates. They have specific information to gather, ideas to formulate, and tasks to complete. The group members then report back to each other and begin to craft solutions and proofs based upon their pooled information. Ultimately, proofs are presented to the rest of the class.

During the presentation the idea of a Proof Circle will be introduced and defined. Sample problems from various courses would be discussed as well as several examples of student work. Assessment tools used to measure efficacy and student reactions upon course completion would also be addressed. (Received August 28, 2009)

1056-Z1-332 **Javad Namazi*** (namzi@fdu.edu), 285 Madison avenue, Madison, NJ 07940. *A Lagrage Interpolation Mean Convergence.*

Let $\alpha$ and $\beta$ be two non-negative finite measures on $[-1,1]$. Let $P_{n,\alpha}$ be the orthogonal polynomial of degree n with respect to $\alpha$ and let $L_{n,\alpha}(f)$ be the interpolation polynomial of degree $n-1$ that agrees with f at the roots of $P_{n,\alpha}$. We investigate conditions on $\alpha$ and $\beta$ that guarantee the convergence of $L_{n,\alpha}(f)$ in $L^p_\beta$ norm for $f$ in $C[-1,1]$. (Received August 29, 2009)

1056-Z1-336 **Thomas Philip Wakefield*** (TomWakefield@gmail.com), Department of Mathematics and Statistics, Youngstown State University, One University Plaza, Youngstown, OH 44555. *Huppert's Conjecture and $PSp_4(q)$.*

In the late 1990s, Bertram Huppert conjectured that the nonabelian simple groups are essentially determined by their character degrees. As part of his work to illustrate the veracity of his conjecture, he showed that if $q = 3$, 4, 5, or 7 and the sets of character degrees of the finite group $G$ and $\mathrm{PSp}_4(q)$ are the same, then $G \cong \mathrm{PSp}_4(q) \times A$, where $A$ is an abelian group. We will remove Huppert's restriction on $q$ and show that the conjecture holds for $\mathrm{PSp}_4(q)$ for all $q > 2$. (Received August 30, 2009)

1056-Z1-351 **Zengxiang Tong*** (ztong@otterbein.edu), Mathematical Sciences Department, Otterbein College, Westerville, OH 43081, and **Zhen Huang** (zhuang@otterbein.edu), Mathematical Sciences Department, Otterbein College, Westerville, OH 43081. *The Extended Law of Total Probability.* Preliminary report.

The law of total probability is a powerful technique in solving probability problems. However, it is not emphasized enough in most probability textbooks. This paper presents two extended forms of the law of total probability, related with discrete and continuous random variables. This paper also uses several examples to show the power and advantage of applying the extended law of total probability in solving difficult problems. (Received September 01, 2009)

1056-Z1-354 **Donna M Pierce*** (dpierce@whitworth.edu), Department of Mathematics and Computer Scienc, Whitworth University, 300 W Hawthorne, Spokane, WA 99251. *British Royal Society: A Fraternity of Experimentalists.*

Isaac Newton, John Wallis, Robert Boyle, Robert Hooke, Sir Kenelm Digby, Christian Huygens, Christopher Wren - these are names familiar to us because of their important 17th century discoveries in mathematics and science. But these men were also part of a fraternal scientific society organized for the purpose of promoting "Physico-Mathematical Experimental learning." Their motto was "Nullius in verba" which roughly translates as "Take nobody's word for it." This group of mathematicians, physicians, scientists, theologians and wealthy aristocrats met weekly to view experiments and discuss scientific topics ranging from atmospheric pressure to the effect of mixing the blood of sheep into human veins. The British Royal Society was committed to establishing the truth of scientific matters through experiment rather than through reliance on ancient authorities as was common at the time. Devoted to the promotion of science, the society aspired to be a clearinghouse for scientific knowledge. In this talk we will look at the origins of the British Royal Society, its distinguishing philosophy, its early labors and how it has served as a model for later scientific societies. (Received September 01, 2009)

1056-Z1-356 **Padraig M. McLoughlin*** (mcloughl@kutztown.edu), 265 Lytle Hall, Dept. of Mathematics, Kutztown University of Pennsylvania, Kutztown, PA 19530. *Is Mathematics Indispensable and Are Pre-requisites Needed in Mathematics Courses?*

We argue "Is Mathematics Indispensable & Are Pre-requisites Needed in Mathematics Courses?" that the answer to one question is, 'yes,' and to the other, 'no;' however, the responses to the questions are inverted. The questions were posed in two papers, "Do We Need Pre-requisites" (O'Shea & Pollatsek, 1997) and "Is Mathematics Necessary" (Dudley, 1997), which the author has read (seemingly) every year and has provoked much reflection. The answers to the questions will lead to a discussion of the 2004 CUPM Recommendations. We organise the paper such that we first review the literature and offer a synopsis of the major points that are addressed in the paper. Then, we argue the main points: we need pre-requisites in mathematics courses; but, mathematics is not a necessary are of academia for all students. We continue by discussing CUPM Recommendations and their relationship to the questions. We argue that learning requires doing; only through inquiry is learning achieved, and mathematical thought is one that must be focused on the process of deriving a proof, constructing a solution to a problem, or providing connection between and betwixt the two. Finally, we opine that some of the recommendations are flawed and might need revision for the next set of CUPM Standards. (Received September 01, 2009)

1056-Z1-357 **Walter Meyer*** (meyer1@adelphi.edu), Dep't. of Mathematics and Computer Science, Adelphi University, South Avenue, Garden City, NY 11530. *History of The Return of Applications in Undergraduate Mathematics in the United States.*

At the end of the 19th century, applications played a significant role in the teaching of undergraduate students of mathematics in the United States. This is clear from scholarly work by Florian Cajori, an early president of MAA. But by the middle of the 20th century, applications of mathematics were rare in the undergraduate curriculum. Today, once again, applications are common. This paper will describe the key milestones marking this return of applications in the second half of the 20th century. In addition we will describe what we consider to be the main reasons why applications regained popularity. Some of these reasons are of an intellectual nature, but some concern the impact of social factors on mathematics education. (Received September 01, 2009)

1056-Z1-368 **Bryan V. Hearsey*** (hearsey@lvc.edu), Department of Mathematical Sciences, Lebanon Valley College, Annville, PA 17003. *50 years of College Math. Have I learned anything?* Preliminary report.

Currently the Mathematical Sciences Department at Lebanon Valley College attracts approximately 8% of the new students entering the college each year, and mathematical Sciences students make up approximately 5% of a typical graduating class. This talk will consider some of the fundmental principles behind this success: Satisfied alumni are more important than 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-content is the vehicle not the destination; Students will not work hard unless you do-pedogogy matters; You cannot do it alone-it takes a team. (Received September 02, 2009)

1056-Z1-379 **Ezra Brown*** (ezbrown@math.vt.edu), Math Department, Virginia Tech, Blacksburg, VA 24061-0123, and **Nicholas A. Loehr**, Math Department, Virginia Tech, Blacksburg, VA 24061-0123. *Why is $PSL(2,7) \cong GL(3,2)$?*

We construct a straightforward, explicit bijection from the group $PSL(2,7)$ onto the group $GL(3,2)$. Our proof requires only elementary facts about groups, fields, and matrices. In particular, our proof does not utilize projective geometry, block designs, or simplicity arguments. (Received September 03, 2009)

1056-Z1-387 **Christopher M Davis** and **David G Taylor*** (taylor@roanoke.edu), Department of Mathematics, CS, and Physics, 221 College Lane, Salem, VA 24153. *The Harmonic Series and Biconvergence: One step forward, two steps back.*

Recent interest in the harmonic series has spawned double-, triple-, and multi-harmonic series, in addition to variants of $q$-series. Drawing upon the harmonic series and its counterpart, the alternating harmonic series, we have forged a wonderful series using the positive real line as a basis for adding and subtracting elements of the harmonic series. The number of terms used in each step is given by powers of a fixed base $x \geq 1$. In this talk, we construct a formal illustration of the biconvergence of these series, define what it means to sum a non-integer number of parts, and prove some very interesting results regarding our series. (Received September 03, 2009)

1056-Z1-389 **Jeffrey M Groah*** (jeffrey.m.groah@lonestar.edu), Mathematics Department, 3200 College Park Dr, Conroe, TX 77381. *A connectivity preserving discontinuous function.*

A recently published problem and three distinct solutions concerning functions that are connectivity preserving but nowhere continuous are presented. It is well-known that continuous functions map connected sets to connected sets. Also, there are examples of functions that are discontinuous at one point and yet connectivity preserving. In this session, three constructions of a function that is connectivity preserving but continuous nowhere are discussed. (Received September 03, 2009)

1056-Z1-402 **Emre Tokgoz*** (Emre.Tokgoz-1@ou.edu), 229 Overton Drive, Norman, OK 73071. *On the Theory of Mixed Convex Functions.*

In the queueing systems theory, there are systems where the convexity and minimization of functions with real and integer variables are considered. The developed theories on convexity of both real variable and integer variable functions were not enough to give a precise answer to the convexity of 2-smooth mixed functions. In this paper, improvements in the theory of mixed convexity will be given with applications. (Received September 22, 2009)

1056-Z1-418 **Timothy Grant Hall*** (info@pqic.com), P. O. Box 425616, Cambridge, MA 02142-0012. *Chromatic Methods For Creating A Secure Identification Procurement.*

Chromatic Methods are the mathematical formulations, manipulations, and matrix methods for producing an encrypted, tamper-proof, authenticatable and verifiable identification procurement from a graphical image. Encoding such identification data onto permanent media provides an ultra-secure method for verifying that presented identification data were produced from authorized analytical methods, and/or for authenticating that the presented identification data were produced from an original, unique graphical image. This paper presents the analytical methods and processing steps needed to create this ultimately secure identification procurement. (Received September 05, 2009)

1056-Z1-451 **Jay Stine*** (jstine@misericordia.edu), Department of Mathematics, 301 Lake Street, Dallas, PA 18612. *A New Characterization of Dimension Zero.* Preliminary report.

We consider notions from general topology which can be expressed solely in terms of induced or coinduced topologies, including (in)discrete topologies, product topologies, and quotient topologies, among others. In this paper we discuss some advantages of these notions over others, and then show that the classical notion of dimension zero has such a characterization. By way of application, we employ this new characterization to give a novel interpretation of an equivalence relation on a set. (Received September 08, 2009)

1056-Z1-456 **Meighan I. Dillon*** (mdillon@spsu.edu), Mathematics Department, SPSU, 1100 S. Marietta Pkwy, Marietta, GA 30060. *The Elements of Euclid.*

The Elements of Euclid, dating to around 300 BC, has been in continuous use since it was written. It is arguably one of the most influential texts in history. A codification of geometry and arithmetic as known in 300 BC and as taught at Plato's Academy at the time, The Elements remains a masterpiece of clarity and beauty.

This talk is concerned with the place of The Elements in the history of pure mathematics. A culmination of 300 years of Greek thought, The Elements ushered in a modern age in mathematics, starting a thread that runs strong and clear into the 21st century. In this talk, we examine how Euclid's Elements has not only survived 2300 years but has remained a vital source for teaching and learning. (Received September 08, 2009)

1056-Z1-483 **Sommer L Sprowls*** (sprowlssl@washjeff.edu), 50 S. Lincoln St., Box 1265, Washington, PA 15301, and **Chelsea Cerini** and **Roman Wong**. *The Mystery of the M&m Sequences.*

In a 2005 *CMJ* article, Shultz and Shiflett introduced the idea of M&m sequences. Start with any three numbers $x_1$, $x_2$, and $x_3$. For $n \geq 4$, $x_n$ is defined to be the number such that the mean of $(x_1, x_2, \ldots, x_n)$ is equal to the median of $(x_1, x_2, \ldots, x_{n-1})$. In the article, they proved that any M&m sequence can be transformed into a sequence beginning with 0, $x$, $x+1$ where $x \geq 1$. They showed that these sequences always stabilize with length 73 when $x \geq 21.3125$ and they conjectured that every M&m sequence stabilizes. In our research, we extend their result further and find new observations of our own. We also reveal the mystery behind the number 21.3125 and its significance with M&m sequences. (Received September 09, 2009)

1056-Z1-484 **Chelsea Cerini*** (cerinicl@washjeff.edu), Washingon, PA, and **Sommer Sprowls** and **Roman Wong**. *Set Difference and Jump Sequences.*

The study of set differences dates back to the 1940's by prominent mathematicians, including Erdös, Miller, and Wichmann. Let $A$ be a finite set. Define the set difference $A - A = \{a - a \mid a \in A\}$. Let $n \in \mathbf{N}$. Denote $[n] = \{0, 1, 2, ..., n\}$. Let $A \subseteq [n]$ be a $k$-element subset, and denote the cardinality of $A$ by $|A|$. $A$ is said to be $n$ -complete if $|A - A| = |[n] - [n]|$. That is, the set $A - A$ generates all possible $2n + 1$ differences in $[n] - [n]$. In our studies, we tried to find methods to create the smallest $n$-complete subsets of $[n]$, called bases. We examined processes already investigated by others, such as the modular arithmetic method and the method developed by Wichmann and improved by Miller. We also explored jump sequences, which are created by the differences between values in $A$, and we compiled a list of requirements needed for these sequences to result in complete sets. Our paper combines and details the many different approaches that can be used to create $n$-complete sets, most of which have been scattered about in various places for over sixty years. (Received September 09, 2009)

1056-Z1-516 **Cynthia J Woodburn*** (cwoodbur@pittstate.edu), Dept of Mathematics, Pittsburg State University, 1701 S. Broadway, Pittsburg, KS 66762. *Teaching a Course on Women in Mathematics.* Preliminary report.

The presenter has been teaching a course called "Women in Mathematics" for the past two years. It began as a special topics course to meet the needs of a single student and has quickly grown into a very popular elective course. We'll discuss the course aims and objectives, content of the course, assignments, how it fits into the curriculum, and student reactions. (Received September 11, 2009)

1056-Z1-540 **Daniel Joseph*** (josephds@vmi.edu), Department of Mathematics and Computer Sci., Virginia Military Institute, Lexington, VA 24450, and **Aprillya Lanz** and **Vonda Walsh**. *Overcoming Pre-Calculus Misconceptions in Calculus Using Clickers.*

It is no secret that poor Pre-Calculus skills are a key contributor to high failure rates in first semester college Calculus courses. An impediment to overcoming this problem is that many students think they already know these skills and so they "tune out" any attempt to correct the problems. In this talk we will discuss how the use of clickers allowed us to focus our Calculus students on what they did not know and, in a fun and engaging way, to correct their misconceptions about these common Pre-Calculus stumbling blocks. (Received September 11, 2009)

1056-Z1-541 **Jason J Molitierno*** (molitiernoj@sacredheart.edu), Department of Mathematics, 5151 Park Avenue, Fairfield, CT 06825-1000. *Visualization Projects in Multivariable Calculus.*

Many of the concepts covered in Multivariable Calculus involve three dimensions. In this talk, I describe projects using Maple (which can be adapted to Mathematica) that I give students to assist them in understanding these concepts. Concepts covered in these projects include the quadric surfaces, absolute extrema over a closed region, and cylindrical and spherical coordinates - amongst other topics. These projects enable students to visualize these concepts in a way they would be unable to on a two-dimensional piece of paper or whiteboard. After constructing such graphs, students are required to analyze them. Thus there is a visual component and a written analytical component to these projects. If time permits, I will discuss ways I implement three-dimensional technology in class. (Received September 11, 2009)

1056-Z1-542 **Doreen De Leon*** (doreendl@csufresno.edu), Department of Mathematics, California State University, Fresno, 5245 North Backer Ave., M/S PB108, Fresno, CA 93740.
*Euler-Cauchy Using Undetermined Coefficients.*

The Euler-Cauchy equation is often one of the first higher order differential equations with variable coefficients introduced in an undergraduate differential equations course. Putting a nonhomogeneous Euler-Cauchy equation on an exam in such a course, I was surprised when some of my students decided to apply the method of undetermined coefficients, which is guaranteed to work only for constant-coefficient equations, and obtained the correct answer! It turns out that we can find a particular solution to this equation using a substitution similar to the standard method of undetermined coefficients, if the right-hand side function is of a certain type, without using variation of parameters or transforming the equation to a constant-coefficient equation and then applying undetermined coefficients. (Received September 11, 2009)

1056-Z1-543 **Alan Alewine***, 701 College Road, Lebanon, IL 62254. *A Summer of Knots.*

Students from ethnic minorities have long been underrepresented in research-level mathematics. Summer programs offer the opportunity for such students to strengthen critical skills needed to be successful in both professional and academic careers. We received a grant this past summer to offer a Research Experience for Undergraduates (REU) in knot theory. The REU had three components: a research component, a mathematical communication component (writing and speaking mathematics effectively), and a professional development component (graduate school, careers in mathematics, etc.). We present an overview of our experience. Specific results will also be discussed. (Received September 11, 2009)

1056-Z1-578 **David R Gurney*** (dgurney@selu.edu), SLU 10541, 500 Western Avenue, Hammond, LA 70402. *A Matrix Approach to Linear Statistical Models.* Preliminary report.

This is a proposal for a second course in statistics based on the topic of linear statistical models. Starting from simple examples, techniques will be introduced for estimating model parameters and then used to develop more general formulas. The course would have a linear algebra prerequisite and will use that linear algebra knowledge - matrix methods in particular - to develop single and multivariable linear models and some polynomial models. In the process, concepts of statistics such as the correlation coefficient, degrees of freedom and unbiased estimates will be explained in detail. (Received September 13, 2009)

1056-Z1-604 **Paul E. Fishback*** (fishbacp@gvsu.edu), 1 Campus Drive, Grand Valley State University, Allendale, MI 49418. *A Two-Course Sequence on Mathematical Programming for Undergraduates.*

Linear and nonlinear programming courses can provide students a greater appreciation of the central role linear algebra plays in addressing real-world optimization problems. This talk will describe the speaker's experiences teaching a mathematical programming course sequence having calculus and a first linear algebra course as its prerequisites. A major instructional objective is for students to recognize how basic linear algebra tools lead to fundamental results in the field of mathematical programming. Partitioned matrix multiplication, for example, yields an elegant means for developing duality theory and for performing sensitivity analysis. In these courses students use the graphic, symbolic, numeric, and programming capabilities of Maple to deepen their understanding of important concepts and to complete team projects addressing problems in the areas of transportation, scheduling, machine learning, and finance theory. (Received September 14, 2009)

1056-Z1-609 **Neeraj Bajracharya*** (neeraj@unt.edu), University of North Texas, Denton, TX 76201.
*Level curves of the angle function of a positive definite symmetric matrix.*

Given a real $n \times n$ matrix $A$, write $\phi_A$ for the maximum angle by which $A$ rotates any unit vector: $\phi_A := \sup_{x \in S^{n-1}} \angle(x, Ax)$. Suppose that $A$ and $B$ are positive definite symmetric (PDS) $n \times n$ matrices. Then their Jordan product $\{A, B\} := AB + BA$ is also symmetric, but not necessarily positive definite. If $\phi_A + \phi_B \geq \frac{\pi}{2}$, then there exists $S \in \mathrm{SO}_n$ such that $\{A, SBS^{-1}\}$ is indefinite. Of course, if $A$ and $B$ commute, then $\{A, B\}$ is positive definite. Our work grows from the following question: if $A$ and $B$ are commuting positive definite symmetric matrices such that $\phi_A + \phi_B \geq \frac{\pi}{2}$, what is $\inf \left\{\phi_S : S \in \mathrm{SO}_n, \{A, SBS^{-1}\} \text{ indefinite}\right\}$? In this talk we will describe the level curves of the angle function $x \mapsto \angle(x, Ax)$ of a $3 \times 3$ PDS matrix, and discuss their interaction with those of a second such matrix. (Received September 14, 2009)

1056-Z1-610 **Mindy Beth Capaldi*** (mindy_capaldi@ncsu.edu), North Carolina State University, Department of Mathematics, Campus Box 8205, Raleigh, NC 27695. *$L_\infty$ Algebras and Symmetric Braces.*

This presentation introduces $L_\infty$ algebras, symmetric braces, and $L_\infty$ morphisms, provides examples of each, and then shows how we can use $L_\infty$ morphisms to derive new $L_\infty$ algebras from existing ones. The proof that we do indeed have a new $L_\infty$ algebra is in the context of symmetric brace algebras. We can demonstrate this process with a concrete example where we start with a small, but nontrivial, $L_\infty$ algebra as well as a simple set of morphisms. (Received September 14, 2009)

1056-Z1-636 **Christopher S Frayer*** (frayerc@uwplatt.edu), University of Wisconsin-Platteville, Math Department, Platteville, WI 53818. *Polynomial Root Motion.*

A polynomial is determined by its roots and its leading coefficient. If you set the roots in motion, the critical points will move too. Using only tools from the calculus sequence, we'll find an inverse square law that determines the velocities of the critical points in terms of the positions and velocities of the roots. (Received September 15, 2009)

1056-Z1-643 **Katherine Heller*** (kheller@virginia.edu), Department of Mathematics, P.O. Box 400137, University of Virginia, Charlottesville, VA 22904-4137. *Composition Operators on $S^2(\mathbb{D})$.*

Given $\varphi : \mathbb{D} \to \mathbb{D}$, an analytic map of the unit disc in $\mathbb{C}$, the composition operator $C_\varphi$ is defined by $C_\varphi(f) = f \circ \varphi$ for $f$ belonging to some Hilbert space of analytic functions on $\mathbb{D}$. In this talk, we will discuss properties of linear-fractionally induced composition operators and their adjoints on the Hilbert space of functions whose derivative is in the Hardy space, $H^2(\mathbb{D})$. (Received September 15, 2009)

1056-Z1-646 **Mohamed Allali*** (allali@chapman.edu), One University Drive, Chapman University, Orange, CA 92866. *Mathematics in Signal Processing.*

Signal processing is becoming a strong application area of modern mathematics. In this talk, I will show strong connections between mathematics and digital signal processing through practical examples that can be incorporated into many mathematics courses. (Received September 15, 2009)

1056-Z1-653 **Hieu D Nguyen*** (nguyen@rowan.edu), Rowan University, Department of Mathematics, 201 Mullica Hill Rd., Glassboro, NJ 08028. *Foot to the Pedal: Generalizing Euler's work on constant pedal curves to constant pedal surfaces.* Preliminary report.

In this talk we describe Euler's solution to the problem of finding constant pedal curves published in his E236 paper and discuss a generalization of his work to constant pedal surfaces, a higher-dimensional analogue of constant pedal curves. Some new results describing constant pedal surfaces will be presented. This topic is highly suited as a project for an undergraduate course in differential geometry. (Received September 15, 2009)

1056-Z1-676 **Min-Lin Lo*** (mlo@csusb.edu), Department of Mathematics, 5500 University Parkway, San Bernardino, CA 92407. *Fun and Motivational Activities for Exam Review Day.*

Are you sick and tired of the traditional ways to do exam review? Not enough time to answer all students' homework questions (especially in a proof class) on the day before the exam? Or feel the traditional way is too passive and not effective? Try playing a math jeopardy game or creating a student poster competition!! I've tried both in my senior level real analysis classes with positive feedback from the students. In this talk, I will share the detail of how to employ either one of these so that you can use it right away in your class! (Received September 15, 2009)

1056-Z1-683 **Katerina G. Tsakiri*** (kt125852@albany.edu), Department of Mathematics and Statistics, 1400 Washington Ave., State University of New York at Albany, Albany, NY 12222, and **Igor G. Zurbenko**. *Effect of noise in Canonical Correlation Analysis with application to Ozone Pollution.*

We analyze the effect of independent noise in canonical variate pairs as well as the principal components of k normally distributed random variables with given covariance matrix. We show that the canonical variate pairs as well as the principal components determined from a joint distribution of original sample affected by noise can be essentially different in comparison with those determined from original sample. However, when the main eigenvalues of the original covariance matrix are all distinguishable, the effect of small noise proved to be negligible. We support the theoretical results by using simulation study and examples. The results of the theory are applicable in any field for the decomposition of the components in multivariate analysis. Application of the theory for studying the ozone problem is provided. (Received September 15, 2009)

1056-Z1-689 **Shanzhen Gao*** (sgao2@fau.edu), Department of Mathematics Sciences, Florida Atlantic University, 777 Galdes Road, Boca Raton, FL 33431. *Some Results, Problems and Conjectures On Generalized Markoff Numbers.*

A Markoff number (named after Andrei A. Markoff) is a number that appears in a positive integer solution to the equation $a^2 + b^2 + c^2 = 3abc$ (known as the Markoff equation). The (generalized) Markoff Numbers has been the subject of considerable study. We will present some new results, problems and conjectures on the generalized Markoff Numbers. (Received September 15, 2009)

1056-Z1-707 **Donna LaLonde** and **Jennifer D. Wagner*** (jennifer.wagner1@washburn.edu), Department of Mathematics and Statistics, Washburn University, 1700 SW College Ave., Topeka, KS 66621. *Using Wikis to Enhance Mathematical Communication and Develop Students' Investment in Mathematical Community.* Preliminary report.

In an attempt to increase our students' understanding of key concepts, to give them practice communicating their understanding to their classmates, and to give them a sense of mathematical community, we used content-based wikis in our linear and abstract algebra courses during the Fall 2009 semester. We will discuss what we did and our impressions of the results, including student feedback. (Received September 16, 2009)

1056-Z1-734 **Dianna J Spence*** (djspence@ngcsu.edu), NGCSU Dep't. of Math & Computer Science, 82 College Circle, Dahlonega, GA 30597, and **A. Robb Sinn** and **Brad Bailey**. *Using Authentic Discovery Projects to Improve Student Outcomes in Statistics.* Preliminary report.

We report activities & findings of a 3-year project, "Authentic, Career-Specific, Discovery Learning Projects in Introductory Statistics," funded by the National Science Foundation. The project scope includes: 1) developing teaching materials for using discovery projects to teach statistics; 2) training instructors to use the materials developed; and 3) evaluation of student outcomes, in both content knowledge and attitudes toward statistics. With an interdisciplinary team of instructors, materials were developed to assist the teacher in facilitating projects using linear regression and t-tests. Five pilot instructors used these materials in their classes. Data collected included qualitative data regarding teacher observations while employing the materials, as well as quantitative data about student performance and attitudes. Before the pilot phase, preliminary data suggested that students in classes using discovery projects achieved higher content knowledge and stronger perceived usefulness of statistics than did their traditional class counterparts. Further analysis from the pilot of the materials confirms that students using discovery projects achieve higher content knowledge, as well as stronger self-beliefs about their ability to understand and use statistics. (Received September 16, 2009)

1056-Z1-735 **Brad Bailey*** (bbailey@ngcsu.edu), NGCSU Dep't. of Math & Computer Science, 82 College Circle, Dahlonega, GA 30597, and **Dianna J. Spence**. *Path elongation and $r$-reduced cutting numbers of cycles.*

For a positive integer $r$ and an edge-wise disjoint collection of cycles, $\{C_i : 1 \leq I \leq n\}$, within a connected graph $G$, the $r$-reduced cutting number is the number of components of order at least $r$ contained in the graph $G - \bigcup_{i=1}^{n} C_i$, while the cutting power of a graph is the smallest number of edge-wise disjoint cycles that have $r$-reduced cutting number greater than 1. We present a series of results calculating the maximum and minimum numbers of edges in graphs with order $n$ and $r$-reduced cutting number $k$ and establishing these values for some important families of graphs. We also introduce the notion of path elongation; for a pair of vertices, $u$ and $v$ within $G$, the path elongation for $u$ and $v$ relative $C$, is the length of shortest path from $u$ to $v$ within $G--E(C)$ minus the length of the shortest path from $u$ to $v$ within $G$, or $dist(u,v,G)--dist(u,v,G-E(C))$. We consider two possible definitions of the path elongation value for a graph $G$ and show that they are equivalent. The path elongation value of a graph is related to the notion of a detour length, but can be demonstrated to differ from detour length. (Received September 16, 2009)

1056-Z1-754 **Nancy Carol Buck*** (nancy.buck@gmail.com), 2207 Spring Garden Street, Apt. 2B, Greensboro, NC 27403. *Higher Reciprocity.* Preliminary report.

We will discuss some classic higher reciprocity laws in algebraic number theory and various proofs that have been given for these laws. (Received September 16, 2009)

1056-Z1-791 **Harshini Fernando***, Purdue University North Central, 1401 S. US Hwy 421, Westville, IN 46391. *Likelihood Inference for Nonlinear Regression Models.*

We consider a special case of the nonlinear model. In the linear regression model when the design matrix X is a function of unknown parameters, it is a conditionally linear nonlinear regression models. We develop new techniques for making inferences about the unknown parameters in the conditionally linear nonlinear model. Closed form expressions for the robust likelihood functions for unknown parameters are derived, against departures from the normal errors in the direction of spherically contoured error distributions. Several well-known examples are considered and Monte Carlo simulation results are presented. (Received September 17, 2009)

1056-Z1-797 **Molli R. Jones*** (mjones2@immaculata.edu), Deptartment of Math/CS/Physics, P.O. Box 648, Immaculata, PA 19345-0648. *Integrating Mathematical Modeling into Science and Mathematics Curricula in Challenged School Districts.*

Imagine what can happen when mathematics and science professors work with NASA scientists to help dedicated K-12 teachers understand mathematical modeling and the scientific process. The Partnership in Math and Science aims to improve the math and science abilities of upper-elementary and secondary teachers in challenged greater Philadelphia-area school districts. With their increased knowledge of mathematics and science, teachers gain the confidence necessary to complement the textbook with less-conventional methods in the classroom. During the 2009-2010 school year, the teachers are working with NASA satellite data to answer research questions that were formulated by NASA scientists and education specialists. The teachers will then integrate their knowledge of mathematical modeling, data analysis, NASA missions, and space science to cooperatively create and implement unit plans that actively involve students in the scientific process. The Partnership in Math and Science is a Mathematics and Science Partnerships (MSP) Program supported by the U.S. Department of Education (http://www.ed-msp.net/). (Received September 17, 2009)

1056-Z1-827 **Jose Maria Menendez*** (jmenendez2@radford.edu), 705 S Main St Apt A1, Blacksburg, VA 24060. *Mathematics workshops for parents and children as hybrid spaces.*

In this presentation we analyze the interactions among participants as they work on mathematical problems in the context of a workshop for parents and children. We focus our analysis on 3 themes: The role of language (how do parents and children use English and Spanish to negotiate their mathematical interactions?); the role of collaboration (how do authority [as in being the mother] and expertise [as in knowing the mathematics] play out when working on a problem together); and the role of a third party (how a facilitator or other participant is invited to intervene when an impasse in a group arises). We use vignettes to illustrate these themes and to underscore hybrid spaces as opportunities for learning. (Received September 17, 2009)

1056-Z1-833 **A. Dale Magoun*** (magoun@ulm.edu), University of Louisiana @Monroe, Dept of Mathematics & Physics, Monroe, LA 71209, **A. Serpil Saydam** (saydam@ulm.edu), University of Louisiana@Monroe, Dept of Mathematics & Physics, Monroe, LA 71209, and **Charlotte H. Owens** (owens@ulm.edu), University of Louisiana@Monroe, Monroe, LA 71209. *Reversing the Pattern of Low Performance in College Algebra Using the National Center for Academic Transformations' Roadmap Model.*

Mathematics classrooms at many universities have incorporated new approaches to student learning by the National Center for Academic Transformations' (NCAT) roadmap to redesign (R2R). This article discusses each of the major components of designing a new technology-based curriculum, the development of a mathematics resource center to support the curriculum, and the results of two years of the implementation of the R2R approach at our university. (Received September 17, 2009)

1056-Z1-834 **A. Serpil Saydam*** (saydam@ulm.edu), University of Louisiana @ Monroe, Dept of Mathematics & Physics, Monroe, LA 71209, **A. Dale Magoun** (magoun@ulm.edu), University of Louisiana @ Monroe, Dept of Mathematics & Physics, Monroe, LA 71209, and **Charlotte H. Owens** (owens@ulm.edu), University of Louisiana @ Monroe, Dept of Mathematics & Physics, Monroe, LA 71209. *Strategies of Designing College Algebra with Modular Approach.* Preliminary report.

Modularity divides College Algebra into three distinct courses which run approximately 5 weeks in length. Students must master the content of a module before they are permitted to move forward. Thus, some students will finish college algebra within the regular semester while others will transcend the semester boundaries. In summary, modularity is very much like having mini-semesters within the academic year. This talk will discuss each of the major components of designing a new modular approach. (Received September 17, 2009)

1056-Z1-874 **Peter Staab*** (pstaab@fsc.edu), Dept. of Mathematics, Fitchburg State College, 160 Pearl St., Fitchburg, MA 01420, and **Michael Andrade**, Dept. of Mathematics, Fitchburg State College, 160 Pearl St., Fitchburg, MA 01420. *The Role of Permutatation Matrices in Magic Squares.* Preliminary report.

Magic squares from a mathematical point of view are matrices with restrictions on each column and row sum as well as the sum of the diagonals. It has been known for centuries that some matrix operations (that result in rotations and reflections) on magic squares result in other magic squares. A group of us have discovered that classes of permutation matrices (one of which we call magic permutation matrices) can be used to convert a magic square to another related magic square. This has some consequences in the counting of magic squares of a given order as well as a way to generate new ones. In this talk I will show how these permutation matrix classes plays a role in understanding various properties of magic squares. (Received September 18, 2009)

1056-Z1-875 **Louis Beaugris*** (Lbeaugri@kean.edu), 1000 Morris Ave, C-233, Department of Mathematics, Union, NJ 08073, and **Pablo Zafra** and **Kikombo NGoy**. *Experiences in Recruting, Retention and Graduation in the Kean STEM Scholarship Program.*

The Kean STEM Scholarship Program is a 4-year NSF-funded project designed to increase the number of majors in the STEM disciplines. We will present our experiences from the first 3 years of the program. The first cohort of scholars has recently graduated, while the second cohort is in their final year. We will report on our remarkable retention and graduation rates, and share our ideas on what works and what does not in our activities. (Received September 18, 2009)

1056-Z1-876 **Amanda I Beecher*** (amanda.beecher@usma.edu), PO Box 57, West Point, NY 10996, **Hilary DeRemigio** (hilary.deremigio@usma.edu), 646 Swift Road, MADN-MATH, West Point, NY 10996, and **Gerald Kobylski**, 646 Swift Road, MADN-MATH, West Point, NY 10996. *Mathematics and English: A Joint Venture.*

How can we help our students become better communicators? We have found that focusing on communicating mathematical concepts alone may not be the answer. We have collaborated with the Department of English to tackle this issue from two perspectives. In the freshman math modeling course, we have students write a report using mathematics to solve a real world problem. We assess the students on how well they communicate in this project as well as on content using guidance on writing standards from the Department of English. Upon returning them, the English department has students analyze their writing approach and its effect on their presentation of ideas using the feedback from the math instructors. Our initial results suggest that this interdepartmental approach is helping students become better communicators. This talk will overview the development and implementation of this interdepartmental project and discuss ways we will see it evolving into the future. (Received September 18, 2009)

1056-Z1-879 **Leon Brin*** (brinl1@southernct.edu), Southern CT State University, Math Department, New Haven, CT 06515. *Turtles, and Lizards, and Snakes, Oh My!* Preliminary report.

No, not that kind of reptile. A rep-tile, or replicating tile, is a plane figure for which some number of copies of itself can be fitted together to form a figure similar to but larger than the original. So went the 1940 description of such shapes, the simplest of which are triangles and rectangles. First, we will traverse a varied sample of such shapes. Then, turning this definition around, we will see that certain fractals are rep-tiles. We will finish with a discussion of a natural generalization and a natural restriction of the original definition. (Received September 18, 2009)

1056-Z1-888 **Diane G Fisher*** (dfisher@louisiana.edu), Department of Mathematics, P.O. Box41010, Lafayette, LA 70504, and **Kathleen Lopez**, **Michael Totaro** and **Lee Price**. *Changes in Students' Perceptions about Learning Mathematics in a Redesigned Mathematics Course for Business Majors.* Preliminary report.

In collaboration with faculty from the College of Business, The University of Louisiana Lafayette Department of Mathematics is in the pilot stage of redesigning the Decision Mathematics course for business majors. The emphasis on the redesigned course has been to develop mathematical thinking and communication skills, promote interdisciplinary cooperation, and use computer technology to support problem solving and promote understanding. The results of pre and post assessments of the students' quantitative reasoning and their attitudes about learning mathematics will be discussed. (Received September 18, 2009)

1056-Z1-904 **Keith W. DeGregory*** (keith.degregory@usma.edu), MADN-MATH, United States Military Academy, 646 Swift Road, West Point, NY 10996, **Aaron C. Elliott** (aaron.elliott@usma.edu), MADN-MATH, United States Military Academy, 646 Swift Road, West Point, NY 10996, **William L. Fehlman II** (william.fehlman@usma.edu), MADN-MATH, United States Military Academy, 646 Swift Road, West Point, NY 10996, and **Alex A. Heidenberg** (Alex.Heidenberg@usma.edu), MADN-MATH, United States Military Academy, 646 Swift Road, West Point, NY 10996. *Wii™ Derivatives: Learning Derivatives Through Competition.* Preliminary report.

In an age where technology has fully emerged in college classrooms across the country and intertwined itself with undergraduate calculus curricula, there looms a threat of diminished ability among students to take derivatives and anti-derivatives by hand. To counteract this effect we developed the Daily Derivatives competition for our undergraduate Calculus 1 class at West Point. The scoring and conduct of the competition is loosely based off of the concept of adaptive testing found on standardized tests such as the GRE as well as the scoring algorithms found in many Nintendo Wii games. Incorporating the competition into classroom instruction was left entirely up to the individual instructors; as such we had half our 24 instructors choose to take advantage of this resource. In addition to providing a full description of the resources we developed for the Daily Derivatives, to include the scoring algorithm and implementation, this presentation covers the statistical analysis on its effectiveness. Initial findings based on student performance and feedback show favorable results for the Daily Derivatives competition. (Received September 21, 2009)

1056-Z1-915 **Benjamin J Galluzzo*** (bjgalluzzo@ship.edu), Shippensburg University, Department of Mathematics, Shippensburg, PA 17257. *Click and Tell.*

In an attempt to eliminate the standard "15 minutes of silence" and avoid the ensuing battle to re-engage my class after a quiz, I began to use clickers for weekly assessment. These clicker-based quizzes –more specifically, multiple one question-at-a-time quizzes – provide expected positives to both students and teachers in the form of immediate feedback and easy grading, while also encouraging student interaction in order to make the once "tired" quiz a dynamic learning activity. In this talk I will discuss my quiz format as well as the pedagogical effectiveness as determined by anonymous surveys, discussions with students, and personal observation. (Received September 18, 2009)

1056-Z1-947 **Kathleen D. Lopez*** (klopez@louisiana.edu), Department of Mathematics, P. O. Box 41010, University of Louisiana at Lafayette, Lafayette, LA 70504, and **Diane G. Fisher**, **Michael W. Totaro** and **Lee E. Price**. *Redesigning a Mathematics Course to Meet the Needs of Business Majors.* Preliminary report.

In collaboration with faculty from the College of Business, The University of Louisiana Lafayette Department of Mathematics is in the pilot stage of redesigning its Decision Mathematics course for business majors. The emphasis on the redesigned course has been to develop mathematical thinking and communication skills, promote interdisciplinary cooperation, and use computer technology to support problem solving and promote understanding. This presentation will focus on the major changes to course content and pedagogy. (Received September 18, 2009)

1056-Z1-948 **Jerry C. Obiekwe*** (Accessx@uakron.edu), P.O. Box 411, Orrville, OH 44667. *An investigation of attribution theory with College Algebra students via Mathematics Attribution Scale (MAS): Implications to Teaching and Learning Undergraduate Mathematics.*

Essentially, causal attribution deals with the manner individuals ascribe the causes of their successes and failures. For example, in an achievement motivation task, such as mathematics, students tend to evaluate the outcome of their performance by ascribing their success and failure to ability, effort, luck, or task difficulty. Obviously, attribution ascriptions do have learning implications particularly in a subject matter like mathematics. Students who believe that ability is the only relevant factor in predicting success in basic mathematics as opposed to quality of effort may have difficulty pulling themselves up with their bootstrap in a mathematically sense. Mathematics Attribution Scale (MAS) was developed by Fennema, Wolleat and Pedro(1979) for ascertaining the attributions ascriptions of high school students. This study investigated the psychometric qualities of MAS using college algebra students. The idea is to determine its validity at the college level. The implications to learning and teaching mathematics which are offshoots from this study will be presented as well. (Received September 18, 2009)

1056-Z1-967 **Mohammad Khadivi*** (mkhadivi@hotmail.com), M.R.Khadivi,Professor of Mathematics, Dept. of Math., JSU, Jackson, MS 39217. *Impact of Technology on Mathematics Teaching.*

This talk will focus on:

1. the influence of technology and its pivotal—in many cases, indispensable—role in teaching, research, and solving real-world problems;

2. To elaborate on several conjectures which have been created as a result of advances in technology; and

3. To elaborate and make connections between some of the existing mathematical concepts with the aid of technology. (Received September 19, 2009)

1056-Z1-974 **Thomas Koshy*** (tkoshy@framingham.edu), Department of Mathematics, Framingham State College, 100 State Street, Framingham, MA 01701-9101. *Lobb's Generalization of Catalan's Parenthesization Problem and Forder's Catalan Triangle.*

A. Lobb's investigation in 1999 of a generalization of Catalan's parenthesization problem introduced a class of numbers $L_{n,m}$ and another class of numbers $K_{n,m}$. Both can be extracted from Pascal's triangle, and used to establish that every Catalan number $C_n$ can be expressed as a sum of $\lfloor n/2 \rfloor + 1$ integers.

Arrays $L = (L_{n,m})$ and $K = (K_{n,m})$ can be used to construct an array $C = (c_{n,j})$, studied by H. G. Forder in 1961. Array $C$ gives the number of paths a rook can take from the upper left-hand corner on an $(n+1) \times (n+1)$ chessboard to the lower right-hand corner without crossing the main diagonal. There is a bijection between the set of such paths and the set of well-formed sequences with $n$ pairs of left and right parentheses. The many other properties of $C$ include the fact that $c_{n,j}$ is odd if and only if either $n = 0$ or $n$ is a Mersenne number. (Received September 19, 2009)

1056-Z1-989 **Amanda Katharine Serenevy*** (amanda@riverbendmath.org), 1021 Queensboro, Mishawaka, IN 46544. *Riverbend Community Math Center – Promoting mathematical thinking in local elementary and middle schools.* Preliminary report.

The Riverbend Community Math Center is a relatively new non-profit math outreach organization serving north-central Indiana. Over the past several years, we have cultivated working relationships with several local school districts. We are currently building on those relationships to help launch district-wide initiatives that promote mathematical thinking at the elementary and middle school levels. These initiatives include encouraging the adoption of a curriculum that facilitates mathematical conversations, introducing teachers to a new approach to problem solving that promotes student autonomy, partnering with educational psychologists to educate teachers about essential motivation-related pedagogical techniques, introducing teachers to guided inquiry and project-based learning approaches to instruction, and improving the content knowledge of teachers at all age levels. (Received September 19, 2009)

1056-Z1-1007 **Anand L. Pardhanani*** (pardhan@earlham.edu), Department of Mathematics, Earlham College, Richmond, IN 47374. *A 21st century makeover of a classic introductory differential equations course.*

Advances in computational technology, together with evolving teaching paradigms, have led to a variety of efforts to re-vision content and strategy for teaching introductory differential equations courses. Well-known examples include the Boston University ODE Project, the Connected Curriculum Project, the C*ODE*E Project, and the IDEA project.

These and other similar efforts provide several resources to help instructors develop more modern, interesting and relevant differential equations courses. Despite the availability of these resources, it remains challenging to successfully transform a classic course into an effective modern one. This not only involves making crucial decisions about topics and content, but also successfully integrating them with choice of textbook, teaching and assessment methods, technology resources, application emphases and student interests.

In this presentation I will discuss my approach to reshaping a classic ODE course at a liberal arts college. I will describe my experiments with topic, content and textbook, as well as with teaching and assessment strategies based on mini projects and case studies. The presentation will include pointers on how to find sources for projects and case studies, and how to integrate them in standard ODE courses. (Received September 19, 2009)

1056-Z1-1081 **Charles Waiveris*** (waiveris@ccsu.edu), Math Department, Central Connecticut State University, 1615 Stanley Street, New Britain, CT 06050. *Three Simple Questions about Tetrahedra.* Preliminary report.

Even though tetrahedra are three dimensional objects the basic questions of congruence, similarity, and measure can be approached using two dimensional techniques. Determining analogous statements to the familiar congruence theorems for triangles that can be applied to tetrahedra requires only plane geometry. Similarity is more interesting but requires only plane geometry and algebra. It isn't enough to just specify the angles in each face. Finally just how big is that solid angle at the vertex of a tetrahedron. Or as has been asked, "How pointy is the vertex?". A degree measure of the solid angle can be obtained in terms of the face angles at the vertex. This measure needs only plane geometry and trigonometry to understand and can even be checked with a three dimensional protractor. These simple questions provide fertile ground for further interesting and unanswered questions. (Received September 20, 2009)

1056-Z1-1088 **Milo Schield*** (schield@augsburg.edu), Augsburg College, 2200 Riverside Drive, Dept. of Business Administration, Minneapolis, MN 55454. *SIGMAA-QL 2009 Quantitative Literacy Survey: Preliminary Results.* Preliminary report.

In 2009 the Quantitative Literacy Special Interest Group of the MAA (SIGMAA-QL) sponsored a survey of quantitative reasoning at all US colleges. This survey builds on earlier surveys done by Dr. Lynn Steen (a past-president of the MAA). This survey focuses on the general education QR requirements that are most relevant for liberal arts students in majors that don't have a specific mathematics requirement. The results of this survey will be presented. (Received September 20, 2009)

1056-Z1-1094 **Daniel D. Sheng*** (danieldsheng@gmail.com), Senior Class, Westwood High School, 12400 Mellow Meadow Drive, Austin, TX 78750, and **Myles D. Baker** (Myles_Baker@baylor.edu), Department of Mathematics, Baylor University, One Bear Place, Waco, TX 767987328. *When uniformity must be replaced by non-uniformity: on finite difference approximations of the Black-Scholes equation on non-uniform grids.* Preliminary report.

The Black-Scholes equation has been utilized for modeling option pricing extensively. In a steady situation, the equation can be solved by using finite difference schemes on uniform grids. When the volatility of a financial market creates unpredictable irregularities, however, the uniform numerical methods may lose their accuracy. Non-uniform grids must be introduced to overcome such a loss. This talk will focus on the consistency of the explicit, implicit and leapfrog finite difference schemes for solving the Black-Scholes model on non-uniform grids since the consistency ensures the basic reliability of the underlying approximations. Taylor expansions will be used throughout our analysis. Truncation errors will be derived and discussed. We will show that, when proper temporal and variable spatial derivative approximations, such as the D2 formula, are chosen, the non-uniform algorithms provide satisfactory results for today's turbulent financial market. Numerical experiments via MATLAB programs will be given to illustrate our conclusions. (Received September 20, 2009)

1056-Z1-1107 **Timothy A Lucas*** (timothy.lucas@pepperdine.edu), Pepperdine University, Natural Science Division, 24255 Pacific Coast Highway, Malibu, CA 90263, and **Joseph Spivey** (spiveyja@wofford.edu), Department of Mathematics, Wofford College, 429 N. Church St. CPO#46, Spartanburg, SC 29303. *A Transition Course From Advanced Placement to College Calculus.*

A growing number of students are enrolling at universities with AP credit for Calculus I. This results in Calculus II classes with two very different groups of students, i.e., freshmen and upperclassmen. It is difficult to construct a Calculus II course that caters to the disparate needs of these two groups of students. Mathematics departments across the nation are also debating reform Calculus versus traditional Calculus. The compromise at Duke University is that two Calculus II courses are offered: (1) a Laboratory Calculus course that contains many elements of reform Calculus and (2) a more traditional course. This presents a confusing choice to incoming students. In the Spring of 2007, a group of highly motivated graduate students conducted a review of Duke's Calculus curriculum. As a result, this committee carefully crafted a Calculus II course that would address the needs of incoming students with AP credit and bridge the gap between traditional and reform calculus. We will present these issues, our proposed solutions, our experience with running experimental sections of this course and its future in the Duke mathematics curriculum. This talk may be of interest to faculty or graduate students who want to review calculus courses at their own institutions. (Received September 20, 2009)

1056-Z1-1152 **Galen E. Turner*** (gturner@LaTech.edu), P.O. Box 10348, 600 W. Arizona Ave., Ruston, LA 71272, and **James D. Nelson**, **Kelly B. Crittenden** and **Jane A. Petrus**. *A model for high-school teacher professional development and student learning.*

This paper describes a model that can be readily adapted by other universities seeking meaningful partnerships with K-12 schools. In this program, university engineering and science faculty work collaboratively with high school teachers to present challenging engineering design projects to high school students.

Our program consists of a series of Teacher Workshops for high school teachers, each followed by a Discovery Weekend with their students, and culminating in a challenge weekend. Each project includes a thorough integration of mathematics, science and engineering, thereby leading to a much deeper understanding of how the mathematics and science topics taught in high school are related to engineering design. This approach has led to increased confidence in the high school teachers, increased interest in STEM topics among the students, and a heightened awareness of the role of mathematics in solving real problems facing our society. The collaboration between university faculty and high school teachers maximizes the benefit to the students by having both their regular teachers and university faculty directly involved in their projects. It also demonstrates to the students how diverse teams can often provide better solutions to problems. (Received September 21, 2009)

1056-Z1-1168 **Jeffrey L Poet*** (poet@missouriwestern.edu), Missouri Western State University, Agenstein Hall 101, 4525 Downs Drive, Saint Joseph, MO 64507. *Building on Nature's Inspiration: A NAKFI Synthetic Biology Report.* Preliminary report.

As one of 150 invited participants in the November 2009 National Academies Keck Futures Initiative conference Synthetic Biology: Building on Nature's Inspiration, I will report the outcomes of the NAKFI conference, particularly as they may be relevant to mathematicians and mentors of undergraduate interdisciplinary researchers. (Received September 21, 2009)

1056-Z1-1192 **Kenneth J Bernard*** (kbernard@vsu.edu), Department of Mathematics & Computer Science, Carter G. Woodson Avenue, PO Box 9068, Petersburg, VA 23806. *Projects to Enhance Revised Algebra and Functions.*

Projects have been developed and new ones are being planned to support teachers implement new standards for algebra and functions in Virginia. The new standards require students to analysis and transfer between multiple representations of functions that include algebraic formulas, graphs, tables and words. Student collected data should be an integral part of the process of integrating algebraic concepts in the classroom. Overviews of projects, course contents, and an algebra add-on endorsement program will be discussed. (Received September 21, 2009)

1056-Z1-1195 **Joshua Cooper**, **John Lenz**, **Timothy LeSaulnier**, **Paul Wenger*** (pwenger2@illinois.edu) and **Douglas B. West**. *Uniquely H-Saturated Graphs.*

Given two graphs G and H, we say that G is *H-saturated* if G does not contain H as a subgraph, but the addition of any edge to G completes a copy of H. Furthermore, G is *uniquely H-saturated* if G does not contain H and the addition of any edge completes exactly one copy of H. We determine all uniquely H-saturated graphs when H is a path and when H is a cycle with at most four vertices. In each such case, there are only finitely many uniquely H-saturated graphs. (Received September 21, 2009)

1056-Z1-1205 **Samuel M Hansen*** (hanse139@unlv.nevada.edu), 4505 S. Maryland Parkway, CDC Building 7 Room 720, Las Vegas, NV 89154. *Mathematics and the Internet: The Impact of New Media on a Discipline.* Preliminary report.

It is well known that the Internet could not exists without mathematics. It is not nearly as well known the effect that the internet is having on the discipline of mathematics. It only begins with Wolfram MathWorld and Wikipedia giving the world an easy to search repository of important mathematics results. There are blogs and podcasts that simplify mathematics for consumption by the lay, debunk bad math, and take everyone along on the journey of research. Crowd-Sourcing such as the Great Internet Mersenne Prime Search has found us the largest known prime numbers and allowed any person take part in mathematics. Then there is a completely new style of research pioneered by Timothy Gowers which harnesses massive collaboration to produce new results that has been termed Polymathematics. As host of a podcast in which I interview mathematicians for free distribution I have personally joined the New Media Revolution in mathematics and am well placed to delve into its effects. (Received September 21, 2009)

1056-Z1-1214 **Shing S. So*** (so@ucmo.edu), Dept. of Math. & Comp. Sci., University of Central Missouri, Warrensburg, MO 64093, and **Mahmoud Yousef** (yousef@ucmo.edu), Dept. of Math. & Comp. Sci., University of Central Missouri, Warrensburg, MO 64093. *Inquiry-Based Learning for Middle and High School Mathematics Teachers - Part I.* Preliminary report.

It is a well-known fact that students are coming to college ill-prepared in mathematics. Students spend twelve years learning mathematics in school, but when they start college it is obvious that most of them do not remember the basics in mathematics. In this paper we will present an Inquiry-based method which was given in a summer workshop for middle and high school mathematics teachers. In particular, we will discuss the activities at the workshop and how they would benefit students in learning mathematics. (Received September 21, 2009)

1056-Z1-1217 **Mahmoud Yousef*** (yousef@ucmo.edu), Dept. of Math. & Comp. Sci., University of Central Missouri, Warrensburg, MO 64093, and **Shing S. So** (so@ucmo.edu), Dept. of Math. & Comp. Sci., University of Central Missouri, Warrensburg, MO 64093. *Inquiry-Based Learning for Middle and High School Mathematics Teachers - Part II.* Preliminary report.

A one-week Inquiry-based learning workshop for middle and high school mathematics teachers was conducted at a Midwest regional university. During this workshop, participants learned to develop problem sets for various topics in middle and high school mathematics using the Modified Moore Method. In this paper, we will discuss a few samples of these problem sets as well as the outcomes of the workshop. (Received September 21, 2009)

1056-Z1-1241 **Patti Frazer Lock*** (plock@stlawu.edu), Dept of Math, CS, and Statistics, St. Lawrence University, Canton, NY 13617. *Statistics-Based Calculus?*

We often hear the argument that mathematics majors and/or statistics majors should take an introductory statistics course that is calculus-based. It is helpful for students to see the interplay between the two subjects: using integrals to calculate probabilities from a density function or a cumulative distribution function, for example. Where should students see this connection? The 100-level statistics course focuses on applied data analysis while the 100-level calculus course focuses on derivatives and integrals and their applications. This talk will argue that probability and statistics offers another important application that should be taught more frequently in our calculus courses, freeing the introductory statistics course to focus on applied data analysis – even for math majors. (Received September 21, 2009)

1056-Z1-1279 **Tyler Clark*** (thomas.clark973@wku.edu), 1906 College Heights Blvd. #31082, Bowling Green, KY 42101-1082, and **Tom Richmond** (tom.richmond@wku.edu), 1906 College Heights Blvd. #11078, Bowling Green, KY 42101-1078. *Fibonacci Numbers and Collections of Mutually Disjoint Convex Subsets of a Totally Ordered Set.*

We present a combinatorial proof of an identity for the odd Fibonacci numbers $F_{2n+1}$ by counting the number of collections of mutually disjoint convex subsets of a totally ordered set of $n$ points. We discuss how the problem is motivated by counting certain topologies on finite sets, and relate it to Pascal's triangle. (Received September 21, 2009)

1056-Z1-1282 **Jessica M Mikhaylov*** (jessica.mikhaylov@usma.edu), US Military Academy, Department of Mathematical Sciences, West Point, NY 10996. *Be the Volume: A hands-on method for presenting the estimation of volume under a surface.*

Often calculus students have difficulty visualizing surfaces. This difficulty can hinder a student's ability to understand volume calculations using iterated integrals. This talk will present a hands-on learning experience that can be done in the classroom in which the students themselves become the function values on a defined domain. The presentation includes a description of the method, pictures of the method being implemented in a classroom, a short discussion of potential issues, and some follow-on activities that can be used to demonstrate Fubini's Theorem and other related concepts. (Received September 21, 2009)

1056-Z1-1286 **Seshaiyer Padmanabhan*** (pseshaiy@gmu.edu), 4400, University Drive, Science and Tech I, Department of Mathematical Sciences, George Mason University, Fairfax, VA 22030, and **Suh Jennifer**, 4085 University Drive, 200 A, Mathematics Education Center, George Mason University, Fairfax, VA. *Improving Mathematical Practices to Prepare K-12 Teachers on Algebraic Connections and Technology.* Preliminary report.

This paper will present the results from the State Council for Higher Education in Virginia (SCHEV) funded K-12 Improving Teacher Quality project called IMPACT: Improving Mathematical Practices through Algebraic Connections and Technology. The goal of IMPACT is to increase student learning by improving teachers' algebraic, technology and pedagogical knowledge in the middle grades at targeted high-need districts and low-performing schools. This project has already impacted over 100 K-12 teachers and administrators with summer institutes focused on mathematics content and pedagogy, follow-up Lesson Study and by establishing a collaborative mentoring network with participants and university faculty. This collaboration has provided sustainable professional learning and a mentoring infrastructure to continue and broaden the impact of this project. We hope to share the results from our work and present effective techniques that K-12 teachers can use in teaching algebra in the classroom. (Received September 21, 2009)

1056-Z1-1292 **Aaron K Trautwein*** (akt@carthage.edu), Department of Mathematics, Carthage College, 2001 Alford Park Drive, Kenosha, WI 53140. *Middle Mathematics Mobilization Program for Middle School Teachers.*

The Middle Mathematics Mobilization Program (M3P) was a coordinated effort of the Kenosha Unified School District and Carthage College to increase the content knowledge and teaching skills of grades 6-8 middle school teachers in algebra and geometry. This two-year program was funded through the Mathematics and Science Partnership Program from the Wisconsin Department of Public Instruction and based on the Wisconsin and National Teachers of Mathematics teaching and content standards. Teachers participating in M3P completed five specially designed mathematics courses and two mathematics pedagogy classes. This talk will focus on how the content of these courses and the teacher training led to better student outcomes in learning basic algebra. (Received September 21, 2009)

1056-Z1-1304 **Edward D Smith*** (edward.smith@pima.edu), 2202 West Anklam Road, Tucson, AZ 85709. *The Mathematicians Roll With GEAR-UP.* Preliminary report.

This presentation discusses effective techniques to improve the ability and enjoyment of students in programs like GEARUP, especially for their math experiences. . (Received September 21, 2009)

1056-Z1-1307 **Constance C Edwards*** (edwards_c@calu.edu), Department of Mathematics, 250 University Ave., California, PA 15419-1394. *Generating Pythagorean Triples.*

We are all familiar with the 3–4–5 right triangle, but have you ever tried to find less well-known right triangles to use on a test or in a classroom demonstration? If so, there is a cleaver theorem from number theory that tells you how to generate all such right triangles. In this talk I will show you how to get a graphing calculator to use this theorem to generate the triangles for you. (Received September 22, 2009)

1056-Z1-1309 **Frank Anthony Cerreto*** (Frank.Cerreto@stockton.edu), The Richard Stockton College of NJ, Jim Leeds Road, Pomona, NJ 08240. *Mathematics across the Curriculum: A Twenty-year Retrospective.*

During the past 20 years, a small but potentially powerful initiative has established itself in the mathematics education landscape: Mathematics Across the Curriculum. This paper documents the development of the Mathematics Across the Curriculum movement, following a mathematics problem solving model. Just as new, related problems often arise after we have completed the solution of a current mathematical problem, so too many questions remain regarding the future of MAC. Although preliminary assessments have been favorable, no broad-based evaluation of the impact of MAC has been conducted. To what extent has the promise of increased student understanding of mathematics and its connections to other disciplines been realized? What can be done to overcome logistical obstacles preventing instructors from working together in real school settings? Are changes in institutional culture and relationships among academics merely transitory? Is the development of a strong base of curricular materials coming? In other words, will MAC reach a level of educational permanence, or ultimately be discarded as another interesting, but unmanageable instructional fad? (Received September 21, 2009)

1056-Z1-1311 **Gerald M. Higdon*** (ghigdon@fsc.edu), Department of Mathematics, Fitchburg State College, Pearl St., Fitchburg, MA 01420. *The Blip of the Blop: A Successful Mathematics Major Seminar.* Preliminary report.

The full title of the seminar was "The Blip of the Blop Equals (?) the Blop of the Blip." The single general topic was the interchange of the order of mathematical operations. Many examples will be given and original student results will be presented as well as a report on the positive experience of all participants. (Received September 21, 2009)

1056-Z1-1355 **Curtis Feist*** (feistc@sou.edu) and **Ramin Naimi**. *Why Automobile Sunshades Fold Oddly: An Intruiging Application of Topology.*

Most of us are familiar with Magic Shade "automatic folding" sunshades, even if we don't recognize the actual brand name; these shades for automobile windshields are roughly the shape of a circular disk when "open", and then fold up into a coil of several smaller circles when "closed", thus allowing the shades to be stored in a relatively small space. In this talk we discuss topological ideas that explain, with respect to folding, how these sunshades must behave. (Received September 21, 2009)

1056-Z1-1362 **Carla Currin van de Sande*** (carla.vandesande@asu.edu), School of Mathematical & Statistical Sciences, ASU, 1711 Rural Road, PSA633, Mail Code 1804, Tempe, AZ 85287, and **Frank S. Marfai** (frank.marfai@asu.edu). *Open, online, homework help forums: Fostering a culture in which communication reflects a conceptual orientation toward the attainment of quantitative reasoning and literacy skills.* Preliminary report.

Students from around the world are using open (public), online, homework help forums to seek help from the larger mathematical community. Forums with a spontaneous participation structure allow students to post problem-specific questions that can be viewed and responded to asynchronously by others who have the experience, time, and willingness to help. Investigations of existing forums for mathematical help shows that the nature of these forums ranges from cheat sites (where students are provided with worked solutions) to sites that tend to operate more consistently with pedagogically sound principles of learning and instruction (such as providing hints and/or asking questions). In this talk, I share preliminary analyses of interaction in a help forum designed to nurture a culture in which communication reflects a conceptual orientation. The etiquette of this forum asks participants to: 1) exhibit intellectual integrity by sharing thoughts and not providing solutions; 2) respect the learning process of others through responding and promoting thinking and activity; 3) post with meaning by including explanations and justification; 4) strive to make sense by posting the context of the problem; and 5) build up this learning community through demonstrations of politeness and patience. (Received September 21, 2009)

1056-Z1-1364 **Larry Bouldin*** (bouldincl@roanestate.edu), Mathematics and Sciences Division, Roane State Community College, 278 Patton Lane, Harriman, TN 37748, and **Benjamin King** (kingbb@roanestate.edu), Mathematics and Sciences Division, Roane State Community College, 278 Patton Lane, Harriman, TN 37748. *Dual Enrollment vs Duel Enrollment.*

As more colleges offer mathematics classes in high schools, both administration and faculty face new challenges. This talk will be candid discussion between a Dean and a Professor about the pros and cons of dual enrollment programs. What issues have we encountered? What benefits have we experienced? Who is supporting it? Who is opposing it? (Received September 21, 2009)

1056-Z1-1385 **Lisa A Lister*** (llister@bloomu.edu), 224 Ben Franklin Hall, Dept. of Math, CS, and Stat, Bloomsburg University, Bloomsburg, PA 17815. *Recruitment and Retention: Flip Sides of the Same Coin.* Preliminary report.

In a time when many universities are losing majors, our numbers have steadily grown. Currently, Bloomsburg University has over 250 mathematics majors. In this talk we will discuss the programs our department has implemented, such as high school visits and major specific classes for our incoming freshmen, which are designed to not only recruit majors, but retain them as well. (Received September 21, 2009)

1056-Z1-1422 **Rachel R Roe-Dale*** (rroedale@skidmore.edu), Skidmore College, Mathematics and Computer Science Department, 815 North Broadway, Saratoga Springs, NY 12866, and **Emese Lipcsey-Magyar** and **Kimberly Frederick**. *A Biexponential Model of Electroosmotic Flow.* Preliminary report.

Electroosmotic flow (EOF) describes the induced fluid flow at the interface between a buffer solution and a charged surface upon application of an external potential. One of EOF's main applications is in capillary electrophoresis, an analytical chemistry separation technique. For sample reproducibility, a mathematical model of EOF in a dynamic buffer system would be advantageous. Several models exist, but these models do not capture the observed trends in real-time data. We examine a series of data sets, and ultimately conclude that EOF as a function of time, $v(t)$, is most appropriately modeled by the biexponential function, $v(t) = Ae^{r_1 t} + Be^{r_2 t}$. We reach this conclusion after fitting both experimental and simulated biexponential data with a single exponential function and observing a series of residual plots with polynomial shape which ultimately we show to be indicative of the Taylor series expansion for the missing exponential term. (Received September 21, 2009)

1056-Z1-1423 **Ahmed Kaffel*** (kaffel@math.vt.edu), 1404 J university city boulevard, blacksburg, VA 24060, and **Amel Soualmia** and **Masbernat Lucien**. *Analysis of the secondary Flow effects on an open channel with cross stream variation of the bottom roughness.*

In this study we analyzed the effects of secondary flows on the transverse distribution of the depth average velocity in free surface flows above non-uniform bottom roughness. In a first preliminary step, 3D-simulations were achieved using an anisotropic algebraic Reynolds stress model to determine the wall friction and the dispersion terms present in the depth averaged momentum equation. In a second and fundamental step closure assumptions of these terms were tested to define a 2D-Saint Venant model which is solved to calculate the transverse profile of the depth-averaged velocity. This approach was applied to opened channels with periodic transverse variation of the roughness with reference to some available experimental results. This process could allow analyze of scale change problems. Keywords: 2D-Saint Venant equations; wall friction; Secondary flows ; Roughness; free surface flows; Dispersion ; Turbulence (Received September 21, 2009)

1056-Z1-1440 **Kathleen M Clark*** (drkclark@gmail.com), School of Teacher Education, 1114 West Call Street, Tallahassee, FL 32306-4459. *History as a meaning-making tool: Illuminating prospective mathematics teachers' knowledge of algebra.*

The use of history of mathematics in teaching has long been considered a tool for enriching students' mathematical learning. In the United States few research efforts have investigated how the study of history of mathematics contributes to one's mathematical knowledge for teaching. In this paper, I share the results of research conducted over four semesters in which I sought to characterize what prospective mathematics teachers (PMTs) understand about the topics that they will be called upon to teach in the future. In particular, I focus on how the study and application of the history of solving quadratic equations illuminated what PMTs know (or do not know) about an essential secondary school algebraic topic. Additionally, I discuss how the results signal important considerations that should be undertaken by mathematics teacher preparation programs with regard to connecting PMTs' mathematical and pedagogical knowledge, and their ability to engage in historical perspectives to improve upon their own and their students' understanding of solving quadratic equations. (Received September 21, 2009)

1056-Z1-1443 **S. L. Yap*** (syap47@gmail.com), Math/CS Department, 25800 Carlos Bee Blvd., Hayward, CA 94114. *Visualizing and Utilizing the Symmetry Method for Differential Equations.*

The symmetry method is a powerful, beautiful, and widely applicable technique for integrating differential equations. The method, pioneered by Sophus Lie in the latter part of the twentieth century, exploits the invariance of the equation under certain transformations in order to find a coordinate system for which the equation simplifies greatly. For first-order ordinary differential equations, the method turns any differential equation with a continuous family of symmetries into a separable equation.

Many of the techniques taught to handle specific problems such as exact and homogeneous equations, are just instances of this method. In addition to explaining the method and applying the method to several non-linear ordinary differential equations, we highlight the geometric nature of the symmetry method with many graphics and animations. (Received September 21, 2009)

1056-Z1-1448 **Jeremy Case*** (jrcase@taylor.edu), Taylor University, 236 W. Reade Ave, Upland, IN 46989. *Reflection Papers on the Big Ideas.*

What mathematical ideas should students carry with them years after a course ends? For many undergraduates, their sole focus during and after a course is on technique and symbolic manipulations rather than the broader concepts and applications. Reflection papers can be used to help students identify and review the important parts of a course. The presenter was part of a faculty learning community which explored the use of reflection papers as a learning tool. Rather than write about how they met the course objectives, students reflected on the "big ideas" of the course. According to Ken Bain's book, *What the Best College Teachers Do*, a characteristic of exceptional teachers is that they find and ask the "big questions" within their specific discipline, believing that students learn best when they care about finding the answer or adopt a goal they want to reach. In this session, the presenter will provide various "big ideas" reflections he has used in mathematics courses, report on the findings of other members of the learning community, and share how the process of developing the writing prompts significantly changed the community's approach towards teaching and course design. (Received September 21, 2009)

1056-Z1-1458 **Yajun Yang*** (yangy@farmingdale.edu), Department of Mathematics, Farmingdale State College, 2350 Broadhollow Road, Farmingdale, NY 11735, and **Katherine Zhu** (kzhu25@gmail.com), Massachusetts Institute of Technology, Cambridge, MA 02139. *A Classroom Project on Protecting Social Security Numbers from Identity Theft.*

According to security experts, identity theft is one of the fastest growing crimes in America. Social Security Numbers (SSNs) can be used to help assume the identity of other individuals and commit fraud. With an estimated 10 million individuals being victimized by identity theft each year, preventing SSNs from being stolen has become increasingly essential to help protect individuals.

This presentation can work well in the classroom (including a project for a Discrete Mathematics course) to illustrate an interesting method to protect personal information and prevent identity theft. Students can encrypt SSNs in order to generate other unique numbers that can be used for non-social security purposes, such as student identification cards, health insurance accounts, and medical records. The method can be computer implemented and will: encrypt an SSN into an Identification number (ID), and then recover the SSN from the ID number. Therefore, there would be no need to store the SSN in the computer system. (Received September 21, 2009)

1056-Z1-1500 **Brian Bies**, **Kathryn Dabbs** and **Hao Zou*** (hzou@macalester.edu), 1600 Grand Avenue, St Paul, MN 55105. *On Determining the Number of Clusters–An Empirical Study of Different Algorithms.*

In this paper, we perform the first empirical tests comparing several existing algorithms for determining the number of clusters in a data set (the gap statistic, X-means, G-means, data spectroscopic clustering and self-tuning spectral clustering). We use a large number of data sets randomly generated with varying distributions (normal and uniform distributions) and parameters (dimensions, number of clusters, number of data points per cluster, and degree of separation between points). The results show that G-means and X-means perform best on the majority of test cases. In addition, the gap statistic returns good estimates for fewer dimensions and number of clusters, but is less accurate and much slower when the number of clusters and dimensions increases.

We therefore explore ways to improve the gap statistic, and formulate the problem in the simplified continuous context to consider its theoretical basis. (Received September 22, 2009)

1056-Z1-1502 **Cheryl Beaver** (beaverc@wou.edu), Mathematics Department, 345 N. Monmouth Ave., Monmouth, OR 97361, and **Scott Beaver*** (beavers@wou.edu), Mathematics Department, 345 N. Monmouth Ave., Monmouth, OR 97361. *Does Peer Assessment Help Improve Mathematical Writing for Pre-Service Elementary and Middle School Teachers?*

On a study conducted in a core Foundations of Mathematics course sequence for elementary teachers, we use hypothesis testing to investigate the thesis that peer-grading helps future elementary teachers improve their own attitude toward their own mathematics writing skills. Study participants were asked to provide Likert-type scale responses to a sequence of questions regarding their perceptions of their ability to write mathematics and to assess written mathematics, before and after the course sequence. Students in the grading group were asked to perform a sequence of scored peer-grading exercises during the course sequence, while those in the control group were not. The methodology and results of the study are presented, along with students' open comments. (Received September 22, 2009)

1056-Z1-1516 **Shiojenn Tseng*** (topology@mail.tku.edu.tw), 151 Ying-Chung Road, Tamsui, Taipei, 25137, Taiwan, **Jen-Chienh Lo** (m8813026@yahoo.com.tw), 151 Ying-Chung Road, Tamsui, Taipei, Taiwan, and **Wing-Sum Cheung** (wscheung@hku.edu.hk), Porkfulam Road, Hong Kong. *Some Nonlinear Delay Integral Inequalities On Time Scales.* Preliminary report.

In this paper, we establish some finite difference inequalities, relating to a certain delay integral inequality of Ou-Iang type generalized by Pachpatte, on time scales. (Received September 22, 2009)

1056-Z1-1517 **Sang-Gu Lee** (sglee@skku.edu), 300 CheonCheon-Dong, Jangan-Gu, Suwon, GyeonggiDo 440-746, South Korea, and **Kyung-Won Kim*** (kwkim@skku.edu), 300 CheonCheon-Dong, Jangan-Gu, Suwon, GyeonggiDo 440-746, South Korea. *Mathematicians Card and Poster.* Preliminary report.

We introduce a card of 54 mathematicians with a poster that we made. Half of those are for western mathematicians and the rest half are for oriental mathematicians. There are 4 groups of distinct cards. In the process to make such a card with students, we experienced a great deal of Mathematics. It can be used as a part of a history of mathematics course. We like to share our experience for teaching of mathematics and history. (Received September 23, 2009)

1056-Z1-1538 **Judith Lynn Gieger*** (lgieger@oglethorpe.edu), Oglethorpe University, 4484 Peachtree Rd. NE, Atlanta, GA 30319. *Algebra in the K-5 Mathematics Curriculum: Keeping the Promise of Algebra for Every Age.*

The National Council of Teachers of Mathematics recommends viewing algebra as a content strand from kindergarten on. Even though algebra often does not receive explicit treatment until middle school or high school, much of the symbolic and structural emphasis in algebra can build on students' extensive experiences with number in the early grades. The Curricular Focal Points (also produced by NCTM), however, indicate that state curricula prescribe only a nominal treatment of algebra, either explicitly or implicity, in the early grades. When the algebra strand is addressed, the focus is almost exclusively on the development of patterns, with little attention paid to the other ways in which students' extensive experience with number and operations can support the development of algebraic competency. In this presentation, we will discuss how mathematicians involved in the education of K-5 teachers can address this gap by making explicit the connections between predominant K-5 number and operations concepts and the algebraic skills they support. (Received September 22, 2009)

1056-Z1-1543 **Adam V Lewicki*** (adlewicki@davidson.edu), PO Box 6245, Davidson College, Davidson, NC 28035, and **Robert Whitton**. *Well Behaved Rotation About Planar Non-linear Curves: An analysis of the volume and uniqueness of a solid swept out by rotation about a non-linear axis.* Preliminary report.

Pappus' Theorem sweeps a fixed plane about a curve in space, this curve is commonly considered to be the Cartesian axis. We extend this theorem to sweep a "well behaved" curve about a non-Cartesian (non-linear) curve. This "well behaved" curve creates a unique but varying plane at every section of the rotation. We conjecture that if a rotation about a curve is unique and one-to-one at every point in the rotation, and exists in a tubular neighborhood of a given planar axis of rotation, there is a standard and analytical method of calculating the volume swept out in the rotation. We also offer conditions on a curve to guarantee that there exists a bijection from the axis of rotation to the curve to be rotated, and that it lies within a given proper tubular neighborhood of the given non-linear axis. To motivate this idea, we offer a novel example of a torus generated by rotating one circle about another circle in the same plane, with a shared center, but distinct radii. (Received September 22, 2009)

1056-Z1-1574 **Fabiana Cardetti*** (fabiana.cardetti@uconn.edu), 196 auditorium Rd, Unit 3009, Storrs, CT 06268, and **P. Joseph McKenna**. *Getting pumped for math: An investigation of student motivations.*

There is a substantial body of research on student motivations and academic achievement at the elementary and high school level, but less is known at the college level. By understanding what motivates students to learn mathematics, instructors can adapt their teaching to help students achieve a level of engagement conducive to mathematics learning. This study examined college students' perceptions of what motivates them to learn mathematics. Our findings were based on the analysis of the students' journal writings about this topic. The analysis revealed six main motivation themes. We will present and discuss these findings, as well as offer recommendations for instructional practices that promote the different motivations described by the students. Areas for further research will also be presented. (Received September 22, 2009)

1056-Z1-1597 **Nicholas Hamblet*** (nick.hamblet@gmail.com), 1039 Preston Ave Apt #4, Charlottesville, VA 22903. *The Orthogonal Tower for* $\Sigma^\infty \operatorname{Emb}(\coprod_m D^n, V)$. Preliminary report.

Given a manifold $M$, we wish to study the (suspension spectrum of the) space of embeddings of $M$ into a vector space $V$, as a functor of $V$. In this talk, we will discuss the case when $M$ is a disjoint union of copies of the standard open ball $D^n$ in $\mathbb{R}^n$, and consider the space of affine embeddings. We provide a natural homotopy limit model for $\Sigma^\infty \operatorname{Emb}(\coprod_m D^n, V)$ and show how to use it to obtain the Orthogonal Tower for this functor. This tower provides best polynomial approximations, in the sense of Weiss, to the embedding functor. (Received September 22, 2009)

1056-Z1-1601 **Tom McMillan** (tcmcmillan@ualr.edu), Department of Mathematics & Statistics, UALR, 2801 South University Ave, Little Rock, AR 72204-1099, and **Jim Fulmer*** (jrfulmer@ualr.edu), Dept. of Mathematics & Statistics, UALR, 2801 South University Ave, Little Rock, AR 72204-1099. *Using Proofs without Words to Explore Rules of Differentiation.*

This talk will describe our experience using geometric proofs without words for the rules of differentiation as a means for getting students to think about the differentiation rules and for coming up with proofs in their own words. We distributed to our students a variety of picture proofs and let them work with partners in developing a written proof that explained the picture proof. Our talk will describe the insights and innovations that students came up with as they used the pictures as a guide for proving the differentiation formulas. This was a required activity of the course, and students presented their results as part of the course portfolio. We felt that this experience helped students develop the confidence to create their own proofs. (Received September 22, 2009)

1056-Z1-1605 **Larry Wayne Lewis*** (llewis@spalding.edu), Spalding University, 845 South Third Street, Louisville, KY 40203. *An Action Research Proposal: 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?* Preliminary report.

Many students in certain quantitative research courses are unable to compare, with surety, the magnitude of decimal numbers as evidenced by their hesitance or inability to quickly and correctly identify whether or not a p-value is less than a given significance level, thereby producing an otherwise obvious "Innumeracy Type" error. Such an error is prompted by student innumeracy that involves making a correct or incorrect null hypothesis rejection (or non-rejection) decision by comparing a correct p-value to the fixed significance level incorrectly. The probability of an "Innumeracy Type" error is perhaps conditioned upon the student's mathematical background and level of acceptance of the prevalent incorrect societal usage of decimal expressions. In an attempt to call 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 proposes a primarily qualitative action research study that will lead to a possible intervention and a future action plan that might improve the andragogical methodology for the teaching and learning of computationally underprepared graduate students enrolled in certain applied quantitative statistical research courses. (Received September 22, 2009)

1056-Z1-1612 **Michael P Saclolo*** (mikeps@stedwards.edu), 3001 South Congress Avenue, Austin, TX 78704. *Calculus Laboratory: A Companion Course to the Lecture.* Preliminary report.

The first semester calculus course at St. Edward's University has a companion laboratory course. This one-credit workshop-style course serves to further and more deeply explore concepts and techniques discussed in the lecture. Major components of the course are discovery-based activities, skill verification exercises, and use of software geared for mathematical use. Students also complete projects to investigate the uses of calculus to applied problems. We shall discuss the genesis, motivation, objectives, and structure of the course, as well as the challenges in implementing it. (Received September 22, 2009)

1056-Z1-1613 **Dominic W Klyve*** (dklyve@carthage.edu), 2001 Alford Park Dr., Department of Mathematics, Kenosha, WI 53140, and **Anna Lauren**. *Uncovering Buffon's Essai d'Arithmetique Morale.* Preliminary report.

Georges-Louis Leclerc, le Comte de Buffon was best known as a naturalist, and played a pivotal role in the foundation of the modern fields of natural history and geology. As a small supplement to his massive "l'Histoire Naturelle", he included a small essay on moral arithmetic (the *Essai d'Arithmetique Morale*), which includes some of the earliest known work applying the rules of probability to the lives and decisions of human beings.

Possibly because this essay appeared as a supplement to a larger work, it received less attention than his natural historical writings, and even today is often discussed only briefly in modern histories of mathematics. In this talk, we will uncover Buffon's work, demonstrate some of the fascinating insights he had into probability, and seek to grant him some of the reputation he richly deserves. (Received September 22, 2009)

1056-Z1-1670 **Douglas B Mathews*** (douglasbmathews@yahoo.com), 1640 Hope Dr, #1017, Santa Clara, CA 95054, and **Jake Askeland**, **Cheuk Wong**, **Miranda Braselton**, **David Von Gunten**, **Jonathan Baptist**, **Duncan McElfresh** and **Slobodan Simic**. *Adapting the Feynman Path Integral for use in a discrete spacetime.*

The Feynman Path Integral is a quantity that gives the probability amplitude of a photon to transition from one point in spacetime to another. This research was part of a program through the San Jose State University CAMCOS undergraduate research program in Spring 2009. Part of the goal of the research was to determine a method of computing the Feynman Path Integral in a discrete universe. We approximated a discrete universe with a large matrix, where each entry is a discrete place in spacetime, so the matrix is the whole of the universe. We were then able to define a probability amplitude for a transition to any space within our universe by defining action in the discrete spacetime. By then taking the geometric series of our matrix of probability amplitudes, we can take into account all paths of any length between two states in spacetime, and determine a quantity much like the Feynman Path Integral. This research was sponsored by Dr. Jeffrey Scargle from the NASA Ames Research Center. (Received September 22, 2009)

1056-Z1-1680 **Dustin D. Keck*** (dustin.keck@usafa.edu), Department of Mathematical Sciences, USAF Academy, CO 80840, and **Michael A. Brilleslyper** (mike.brilleslyper@usafa.edu), Department of Mathematical Sciences, USAF Academy, CO 80840. *Grading Done Right.* Preliminary report.

Grading student work is how instructors provide feedback to their students. Yet, all too often, the grade is simply a letter or number that does not really provide meaningful feedback. In this talk we present a holistic grading rubric refined over several years and now in wide spread use across multiple courses. The rubric sets clear expectations, is versatile enough to use on a wide array of problem and assignment types, and helps with grading consistency in large courses. Most importantly, rather than focusing on points, students must focus on their weaknesses in order to improve their grades. (Received September 22, 2009)

1056-Z1-1687 **Rebekah Dupont*** (dupont@augsburg.edu), 2211 Riverside Ave., Minneapolis, MN 55454. *Mentoring Underrepresented Students in Science and Mathematics.* Preliminary report.

This talk will promote effective strategies for faculty and students funded by various programs supporting undergraduate research. We will consider the following questions: (1) Should strategies for mentors and mentees differ for programs designed to address the needs of underrepresented minority (URM) or low-income first-generation (LIFG) students? (2) What elements should be integrated into orientation sessions for faculty and student researchers? (3) What type of program structures lead to quality research outcomes and successful student development outcomes?

Like many colleges and universities, Augsburg College has multiple funding sources for undergraduate research; some is earmarked for URM or LIFG students, some is not. At Augsburg, students pursue undergraduate research funded by the Department of Education's McNair Scholars program, NSF's Louis Stokes Alliance for Minority Participation (LSAMP), and an internal undergraduate research program called URGO (Undergraduate Research and Graduate Opportunity). LSAMP students must be URM and McNair Scholars must be URM or LIFG, whereas URGO students are selected solely on the merit of their research proposals. The speaker will draw on her experience with these programs over the last ten years. (Received September 22, 2009)

1056-Z1-1697 **Kate G McGivney*** (kgmcgi@ship.edu), 1871 Old Main Dr., Shippensburg University, Shippensburg, PA 17257. *Making Sense of Sampling Distributions: Activities for an Introductory Statistics Course.* Preliminary report.

In this talk we will share classroom activities that have been used in an introductory statistics course to teach concepts related to sampling variability. Beginning students often struggle with making sense out of the sampling distribution of the sample proportion, an idea at the heart of inference. These classroom activities invite the students to investigate sampling distribution concepts using manipulatives and applets and to make conjectures about population parameters based on simulated data. (Received September 22, 2009)

1056-Z1-1712 **Satish C. Bhatnagar*** (bhatnaga@unlv.nevada.edu), 4505 Maryland Pkwy South, Mathematical Sciences, University of Nevada Las Vegas, Las Vegas, NV 89154-4020. *New Materials on History of Mathematics.*

Generally, historical research material is in the form of books, journals and manuscripts. Any search for, 2000-4000 years old manuscripts is out of question. With growing research in ethno-mathematics, a body of work has come out on the non-European roots of mathematics. For instance, India has a long tradition of using writing materials, like bhojpatra, palm leaves, bamboo stripes, and even barks of special trees. Inscriptions on copper plates were used for official deeds and proclamations.

New mindsets have to decipher science and mathematics from magnificent ancient Hindu temples that have survived in south of India, and Southeast Asia. Ancient monuments are the books of knowledge. The measurements of various lengths, angles, directions of sun light, and planetary positions can shed light on every aspect of ancient society.

Besides monuments, the ancient potteries, textiles, coins, clay seals, and terracottas are also sources for history of mathematics. On the surface, 'crude' mathematics may be in geometrical patterns, but the sophisticated one lies hidden, say, in the chemical composition needed to develop these artifacts. Ultimately, it is tied with the existence of necessary and sufficient conditions for the development of mathematics in a society. (Received September 22, 2009)

1056-Z1-1739 **John C. Mayer*** (mayer@math.uab.edu), Dept. of Mathematics, University of Alabama at Birmingham, Birmingham, AL 35294-1170. *Comparison of Inquiry-Based Class Sessions and Lecture in the Context of Computer Assisted Algebra Instruction.* Preliminary report.

In an experiment conducted at a major state university in Fall Semester, 2009, we compare the effect of incorporating inquiry-based group work 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 group work sessions differentially benefit students in terms of mathematical self-efficacy, content knowledge, problem-solving, and communications. All students receive the same computer-assisted instruction component. Students are randomly assigned to a treatment (group work or lecture). Measures, including pre- and post-tests, are described. Statistically significant differences have previously been observed in a similar study of multiple sections of a Finite Mathematics course in Fall, 2008. Many pre-service elementary school teachers take this Basic Algebra course, thus making this course a significant component of preparing K-6 teachers. (Received September 22, 2009)

1056-Z1-1750 **george rublein*** (gtrubl@math.wm.edu), Department of Mathematics, College of William and Mary, Williamsburg, VA 23187-8795. *Science in the Mathematics Classroom.*

Can high-school teachers do applied mathematics, and should they ? We discuss a collection of problems designed for an 'intermediate' algebra course (Algebra 1 ) whose announced aim is an emphasis on applications. Our applications are entirely drawn from the syllabus for middle school science. Falling bodies, satellites, pH, and decay of therapeutic radio-isotopes are simple examples that illustrate the importance of algebraic skills to working scientists and technical people. Would time taken for these kinds of examples diminish scores on 'standard' algebra tests? (Received September 22, 2009)

1056-Z1-1762 **Brigitte Lahme*** (lahme@sonoma.edu), Sonoma State University, CA, **Jerry Morris** (jerry.morris@sonoma.edu), Sonoma State University, CA , and **Elaine Newman** (elaine.newman@sonoma.edu), Sonoma State University, CA. *A Lesson Study in Real Analysis.* Preliminary report.

Lesson study is a form of professional development in the K-12 classroom, which originated in Japan and is becoming increasingly popular in the US. Several Mathematics faculty at Sonoma State University have participated in lesson study projects in K-12 schools as well as in a class for future teachers. Inspired by their work, we adapted the classic lesson study process to work in our upper division Real Analysis course, required for all Mathematics majors.

Instead of a lecture format, we designed group activities that introduced important concepts and gave students a chance to practice the use of difficult theorems. Our focus was on the connection between the epsilon-delta definitions and sequence definitions of key concepts like convergence, continuity and differentiability. In planning and debriefing sessions, we developed mathematical prompts and anticipated student responses, revised existing materials and planned the next lesson involving these connections. Our goals were to gauge their level of understanding at various stages of the course and to see if these group activities actually helped them do mathematics independently.

We will share mathematical activities, classroom video, student feedback, and our personal experiences with the lesson study process. (Received September 22, 2009)

1056-Z1-1768 **Mary Beisiegel*** (`beisiegm@wou.edu`), Mathematics Department, 345 N. Monmouth, Monmouth, OR 97361. *Issues and Obstacles in Preparing Mathematics Graduate Students for Teaching.*

Within mathematics teacher education, mathematics graduate students and the development of their teaching practices have become a focus of investigation. This is important as almost seventy-five percent of mathematics PhDs will become professors at post-secondary institutions dedicated to undergraduate education rather than research. Thus, attending to the manner in which mathematics graduate students develop their teaching practices is crucial in preparing them for their future profession. The most recent research into mathematics graduate students' teaching has examined their classroom practices and connections between their practices and beliefs about teaching and learning. Researchers observed that while the graduate students acquired positive attitudes and beliefs about teaching mathematics, the students did not adopt alternative practices. The purpose of this research project was to uncover the issues and difficulties that come into play as mathematics graduate students develop their views of their roles as university teachers of mathematics. In an effort to inform future programs for mathematics graduate students, I will describe the results of this study, which followed a cohort of students for six months and focused on their understanding of mathematics teaching. (Received September 22, 2009)

1056-Z1-1795 **Chirashree Bhattacharya*** (`cbhattacharya@rmc.edu`), Department of Mathematics, Randolph-Macon College, Ashland, VA 23005. *PTA(9)s fixed under multiplier -1.*

We classify all perfect ternary arrays of energy 9 fixed under multiplier -1. Several new families of such PTAs will be presented along with concrete examples of finite groups in which they appear. (Received September 22, 2009)

1056-Z1-1805 **Katherine S. Kelm*** (`kbyler@csufresno.edu`), 5245 N. Backer Ave. M/S PB 108, Fresno, CA 93740-8001. *Just-in-Time Calculus.* Preliminary report.

In an effort to improve retention in Calculus I at California State University, Fresno, a number of ideas have been implemented in the last six years. One of them is "Just-in-Time" calculus, a two-semester sequence covering the traditional first-semester calculus material with substantial pre-calculus support. Although the retention rate in Calculus I has appeared to improve since the sequence was implemented, other interventions such as placement exams, concurrent "problem solving" sessions for engineering students, and a new team-teaching format may have played a role. We give our preliminary observations on the effectiveness of some of these ideas, including the troubling finding that overall retention in Calculus II has decreased. (Received September 22, 2009)

1056-Z1-1817 **susan e. kelly*** (`kelly.susa@uwlax.edu`), Mathematics Department, University of Wisconsin - La Crosse, 1725 State Street, La Crosse, WI 54601, and **sarah rozner**. *Winifred Edgerton Merrill - She Opened Doors.*

Winifred Edgerton Merrill was the first American woman to receive her Ph.D. in Mathematics. She earned her degree from Columbia University in 1886, a time when women were not allowed to be officially admitted to this male only university. In her thesis, Multiple Integrals, she uses an application of Green's Theorem which would work nicely in a Multidimensional Calculus course. Highlights of her thesis and her life, obtained from published works, archives, and a personal family journal, will detail some of her contributions to mathematics and to the advancement of women. (Received September 22, 2009)

1056-Z1-1837 **Fatma Mete*** (`fm95@cornell.edu`), Cornell University, Department of Fiber Science & Apparel Design, Ithaca, NY 14850. *Geometric Transformations in Design and Their Self-assembling and Self-organizing Structures.*

We present a method for transforming a simple plane figure into another, which is related to it in a definite way, by applying a group of systematic geometric transformations. The method creates certain classes of complex star motifs from a basic plane figure, by applying certain symmetry and transformation rules in chain operations. In these chains, the successive designs are derived from the initial and previous designs in the chain. We demonstrate that design is a 'self-assembly' as well as a 'self-organizing' process, and expansion, figure, motion and symmetry are the only properties in surface design which can be directly represented mathematically. The process which resembles very closely the self-reproduction of biological molecules also sheds light on uncovering the mathematical mystery in different cultural practices and artifacts. (Received September 22, 2009)

1056-Z1-1876 **Gerald Agbegha*** (gagbegha@jcsu.edu), 100 Beatties Ford Road, Johnson C. Smith University, Dept. of Narural Science and Mathematics, Charlotte, NC 28227, and **Nailong Guo**. *Using an Opening Quiz to set the Tone for a College Algebra Course.*

In recent times, I have found it useful to administer an opening quiz in an attempt to set the tone for my college algebra or Precalculus course. It is composed of questions that test the student's knowledge of some fundamental concepts of mathematics relating to such topics as multiplication, division by zero, the coordinate plane, and straight lines. This opening quiz provides us with an opportunity to discuss these topics in a light manner and ease the students into the course having hopefully bridged a little of the gap between their level of preparedness and the expected prerequisite level of understanding of these topics. The quiz is administered around a kind and gentle atmosphere as I make it clear to the students that the quiz will not count against them. Rather, the grade may be used to replace a lower quiz grade later in the semester. In this talk, I will discuss some of my findings on the use of such an opening quiz. Key Words: Opening Quiz, College Algebra, Fundamental concepts of Mathematics (Received September 22, 2009)

1056-Z1-1892 **Kimberly M Vincent*** (vincent.kimberly@gmail.com), 100 Dairy Rd, Dept. of Mathematics, WSU, Pullman, WA 99164-3113. *Teaching For Transfer And High Cognitive Demand Through The Use Of Discourse In Algebra.*

According so Sfard (2008, pp9) "The most common widespread failure in more advanced school-type mathematics is its highly abstract character. Abstracting, the specialty of scientists at large and of mathematicians in particular, has always been a widely valued activity, appreciated for its power to produce useful generalizations."

Vincent asked pre- and in-service teachers to examine the cognitive demand of both mathematical tasks and questions posed during discourse, using Stein, Smith, Henningsen, and Silver's (2000) The Task Analysis Guide (p.16). Analysis of the data revealed that transfer of learning did not occur when learners are presented questions and tasks with low cognitive demand. Vincent also found both the in-service and pre-service teachers were not adept at asking questions in the abstract or general but instead asked questions specific to the context of the task at hand. From this data it appears that both pre-service and in-service teachers need a deeper understanding of and practice in the development of appropriate mathematical tasks and questions in order to elicit high levels of cognitive demand and to encourage transfer of learning. Vincent will share some promising strategies to improve teachers' ability to ask questions that encourage transfer. (Received September 22, 2009)

1056-Z1-1893 **Aprillya Lanz*** (LanzAR@vmi.edu), 430 Mallory Hall, Department of Mathematics & Computer Science, Virginia Military Institute, Lexington, VA 24450, and **Vonda K Walsh** and **Daniel Joseph**. *Promoting Clickers in Mathematics Courses at Virginia Military Institute.*

In this presentation we will discuss the plans and efforts that have been carried out to install the first electronic response system at VMI. Because of the unique environment at VMI, it is a common obstacle across the campus to maintain student's attention in class. The technology was used to foster a transition from a passive to an interactive learning environment in mathematics courses for liberal arts majors. The clickers were used for communication and participation in interactive teaching sessions. We will discuss the impact of using clickers on student's performance and engagement in the classroom. (Received September 22, 2009)

1056-Z1-1896 **Michael D. Miner*** (jcmhs77@aol.com), 65 Edenbrook Dr., Hampton, VA 2666. *Utilizing Web-based Statistical Resources in Teaching Nontraditional Undergraduate Students in Online Learning Environments.*

The challenges facing delivery of a statistics class to nontraditional undergraduate students in nontraditional higher education programs are especially pronounced when the instructions are delivered online. However, a plethora of web-based statistical tools and concepts demonstrations are readily available to undergraduate students, additionally many of these statistical tools and demonstrations are also rich and powerful in scope. Web-based statistical tools and demonstrations range from the extremely simplistic (mundane) to the extremely complicated (theory driven using high level mathematics), however, the key for the 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 statistical concepts and methodologies. A study was conducted in order to understand the optimal method to introduce web based statistical resources into the online classroom and support learning objectives. This presentation will show the results of the study and present an instructional method to capitalize on the wealth of resources available to students to enhance the learning and understanding of statistical concepts. (Received September 22, 2009)

1056-Z1-1898 **Michael D. Miner*** (jcmhs77@aol.com), 65 Edenbrook Dr., Hampton, VA 23666. *Utilizing Web-based Statistical Resources in Teaching Nontraditional Undergraduate Students in Online Learning Environments.*

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1056-Z1-1924 **Darcel H Ford*** (Dford64@comcast.net), Darcel Ford, 5403 Riverfront Dr, Palmyra, NJ 08065. *A Comparative Study of Online and Traditional Classroom Learning of College Algebra for Non-Traditional Students in Non-Traditional Higher Education Programs.*

This study compared distance and classroom learning of college algebra in terms of efficiency and effectiveness. The study sought to further understand the dichotomy (if any) between learning college algebra in the two learning modalities provided to non-traditional students in non-traditional higher education programs. The study also sought to discover evidence based methods to maximize teaching and learning outcomes for all stakeholders. The current results suggest a robust distance learning system for college algebra is a suitable learning medium for students that have routine access to a computer with an internet connection; possesses good basic study skills; are self disciplined; organized; motivated; and willing to adhere to policies on academic honesty. The traditional classroom learning of mathematics does not seem to require similar attributes. Observations from both settings will be presented along with literature that supports findings on the efficiency and effectiveness of learning under the conditions stated. (Received September 22, 2009)

1056-Z1-1941 **Erin Elizabeth Pitney*** (erin_pitney@beavton.k12.or.us), 7528 SW Barnes Rd., Unit D, Portland, OR 97225. *Being a Student Again: My Summer in a Research Experience for K-12 Teachers.*

A math teacher's reflections on a summer doing competitive graph coloring research with a team of undergraduate students. Questions will be answered such as: Why is it important for K-12 math teachers to do research? What was it like to go back to college level mathematics after several years? How can the research experience be incorporated back into the classroom? We will also present some of the research results involving the two-clique relaxed game chromatic number of certain outerplanar graphs. (Received September 22, 2009)

1056-Z1-1976 **Erick B Hofacker*** (Erick.B.Hofacker@uwrf.edu), 214C North Hall, River Falls, WI 54022. *What can your students do with an iPhone or iPod Touch in Math Class?*

Since Apple opened its AppStore in the Summer of 2008, the iPhone and iPod Touch have become powerful tools that could be incorporated into the classroom. By the Fall of 2009, Apple claims to offer over 75,000 apps (some free and some paid) to its users. This presentation will give an overview of the different types of mathematical apps available to users for download through the AppStore. Through the use of this hand-held device, students have access to the following: graphing calculators, computer algebra systems, formula sheets, Wolfram Alpha, clicker-voting, podcasts, and more. Specific apps will be highlighted and examples given to exhibit to participants the number of mathematical tools available to our students without having to carry a laptop to class. (Received September 22, 2009)

1056-Z1-1986 **Joy Moore*** (moorej12@xavier.edu), Xavier University, Department of Mathematics & Computer Science, 3800 Victory Parkway Mail Location 4441, Cincinnati, OH 45207-4441, and **Kenneth Simonson** (simonskw@ucmail.uc.edu), University of Cincinnati, PO Box 210018, Cincinnati, OH 45221-0018. *Over 20 Years of Success in the Emerging Ethnic Engineers Program at the University of Cincinnati.*

In August of 2008, the Emerging Ethnic Engineers Program in the College of Engineering at the University of Cincinnati celebrated its 20th anniversary as a successful, comprehensive program that focuses on the recruitment, retention, academic success, professional development, and timely graduation of underrepresented ethnic minority students. The objectives of the program are accomplished through three interrelated phases: pre-college science and mathematics programs, first-year collegiate programs, and upper-division programs which include undergraduate research and professional development experiences. Mr. Kenneth Simonson, Director of Academics, and Dr. Joy Moore, Director of Cooperative Learning Calculus, will discuss aspects of the program that have enhanced the academic and professional development of undergraduate students. In particular, assessment results of the cooperative learning calculus program, evaluation of the summer bridge experience, recently developed partnerships with the College of Arts and Science, and long-standing business and industry partnerships will be highlighted. (Received September 22, 2009)

1056-Z1-1990 **Kathryn T Ernie***, 206E North Hall, River Falls, WI 54022, and **Maren Gebhard** (maren.j.gebhard@uwrf.edu), 204F North Hall, River Falls, WI 54022. *Using Clickers in a Refocused College Algebra Course – Part II.*

This is the second of two papers which describes how a cohort of instructors chose to incorporate clickers into a refocused college algebra course. Since it is a refocused course, the main emphasis is placed on conceptual understanding, modeling, and real-life application of algebraic topics. Skills and computation are still incorporated into the course, but they aren't the main emphasis. Thus clickers proved to be a great tool for gaining instantaneous feedback from students to better understand how they understand the concepts of the course.

In each section the clicker questions were integrated into the daily lessons so they overlapped with the examples from the lecture, as well as with the problems students solved during class. Example clicker items will be shared with the audience. The authors will describe similarities and slight differences between their uses of the clickers within their own section of the course. They will each describe their own method for incorporating clickers into daily class activities, and how they were used to encourage student discussion within peer groups, to challenge their thinking, and correct potential misconceptions. The authors will discuss the observed effects the use of clickers had on their students during the course. (Received September 22, 2009)

1056-Z1-1992 **Janet L. Braunstein*** (janet.braunstein@usma.edu), Department of Mathematical Sciences, United States Military Academy at West Point, 646 Swift Road, West Point, NY 10996, and **Edward W. Swim** (edward.swim@usma.edu), Department of Mathematical Sciences, United States Military Academy at West Point, 646 Swift Road, West Point, NY 10996. *Can Instructors Award Partial Credit on Multiple Choice Questions?*

Although it is not yet a common practice, introducing multiple choice questions with answers worth differing point values can be an effective, and efficient, way to fairly assess students. This approach has been successfully implemented in three of our first-year courses, differential calculus (for students in our standard track) and multivariable calculus and ordinary differential equations (for students in our advanced track). We share our motivation for introducing this method, as well as the process behind selecting the answer choices and determining their respective weights. Multiple choice questions with the potential for partial credit have been found to be especially useful in testing students' ability to interpret results obtained using a computer algebra system without putting the technology itself into the students' hands during the exam period. We discuss pros and cons encountered in our implementation thus far, along with suggestions for future improvement. We include actual test questions used in all three courses. Although the content of our examples is restricted to the aforementioned topics, the strategies behind the creation of the questions, answers, and point assignments may naturally be applied to testing in other mathematical subject areas. (Received September 22, 2009)

1056-Z1-2012 **Clyde L. Greeno*** (greeno@mathematicsinstitute.org), P.O. Box 54845, Tulsa, OK 74155-0854. *Closing the Gap: How Can Mathematics Instructors Empower Students for Academic Success in Future Mathematics Courses - Insights From the Developmental Psychology of Personal Mathematical Comprehension.*

Excessive drop/fall outs of college students from undergraduate and pre-college mathematics programs or courses are due largely to their being mathematically under-prepared for the next courses they might take – or for courses in which they now are enrolled. Such is visibly severe in the remedial arena of pre-college courses – but less visibly pervasive throughout the undergraduate curriculum.

So arises the question of just what mathematical preparation actually is internally needed by students, so as to anticipate and comfortably achieve gratifying, genuine personal academic success in the respective courses in which they might enroll. Then arises the question of how curricula and instructors might provide them with such mathematical-learning dispositions and powers.

Piaget ascertained, in essence, that functional personal intelligence grows through progressive development of personal theories – which learners use as templates that portray their realities. That also is how mathematical knowledge grows ... within mankind and within individuals.

Via illustrations, this session challenges mathematicians to (SIGMAA) explore how the tenets of developmental psychology can be merged with the nature of mathematical theorizing, to radically improve instructional productivity. (Received September 22, 2009)

1056-Z1-2034 **Mairead K Greene*** (mairead.greene@rockhurst.edu) and **Paula Shorter**. *fUNcO! - A Mathematical Card Game.*

In the calculus sequence at Rockhurst University, we create an active-learning, student-centered classroom where the focus is on deep understanding of concepts. We begin this approach in the very first unit by providing opportunities for our students to develop a deep understanding of what characterizes the growth of different function classes. We do this by considering narrative, graphical, symbolic and numerical descriptions of functions and rate of change; concavity descriptions; loglog and semilog relationships; and difference equations. This approach provides a foundation on which students can build a stronger understanding of the derivative in later work. A question arose - How could we provide opportunities for students to make deep connections between all of these different characterizations? To address this question, we developed a card game which we call fUNcO! fUNcO is a mathematical version of UNO where different function classes play the role of colors and individual cards vary among characterizations. In this talk, we will demonstrate fUNcO and discuss how it has impacted student learning in our classrooms. (Received September 22, 2009)

1056-Z1-2038 **Andrzej Piotrowski*** (apiotrowski@uas.alaska.edu). *Linear Operators and Zeros of Polynomials.* Preliminary report.

To each simple set of real polynomials $\{q_k\}_{k=0}^{\infty}$ and each sequence of real numbers $\{\gamma_k\}_{k=0}^{\infty}$, we can define a linear operator on $\mathbf{R}[x]$ by declaring $T[q_n] = \gamma_n q_n$. We seek to determine conditions under which such an operator preserves reality of zeros. (Received September 22, 2009)

1056-Z1-2039 **Dylan W Helliwell*** (helliwed@seattleu.edu), WA , and **Peter Littig**, WA. *Rolling Archimedean Dice.*

What is the probability of landing on a triangular face when rolling a cuboctahedron? How likely is it to land on a hexagonal face when rolling a truncated tetrahedron? For Platonic dice, symmetry is all one needs to predict the likelihood of landing on a given face. While the consideration of symmetry allows us to say some things about Archimedean dice, it is not enough to determine all probabilities for a given solid. Our goal is to create a simple model to predict these probabilities. Examples show that merely looking at the relative areas of the various faces is insufficient. We provide two alternate approaches, one based on spherical area and the other on "energy well area." In addition to discussing the strengths and weaknesses of these approaches, we also discuss some statistical analysis in relation to our models. Finally, we note that the models we present can be extended to shapes more general than the Archimedean solids. (Received September 22, 2009)

1056-Z1-2042 **Ann Podleski*** (podleska@hssu.edu), Harris-Stowe State University, St. Louis, MO 63103. *Refocused College Algebra at Harris-Stowe State University.* Preliminary report.

Starting in the fall 2008 semester, Harris-Stowe State University has been teaching several sections of College Algebra using the refocused approach initiated by the United States Military Academy at West Point under the direction of Dr. Don Small. Several Harris-Stowe State University faculty members participated in a NSF funded retreat at West Point as part of the program entitled "HBCU Retreat and Follow-On" which helped prepare us to implement several sections of the refocused approach to College Algebra. This paper presents our experience so far, including student success rates and satisfaction with the refocused course, examples of classroom activities and group projects and future direction for the course. (Received September 22, 2009)

1056-Z1-2080 **Tom Fox*** (foxthomasb@yahoo.com), 2700 Bay Area Blvd, Box 139, Houston, TX 77058. *How Might We Prepare Pre-Service High School Teachers to Teach Using Computer Algebra Systems?*

Issues related to the preparation of pre-service high school teachers and teaching using computer algebra systems (CAS) on handheld calculators will be discussed. When might the CAS be used in the high school classroom? How should it be used? How does this impact curriculum & evaluation? How can we prepare them during their teacher preparation program to effectively use the CAS? (Received September 23, 2009)

1056-Z1-2088 **Michael S McClendon*** (mmcclendon@uco.edu), University of Central Oklahoma, Dept. of Mathematics and Statistics, 100 North University Drive, Edmond, OK 73034, and **Charles L Cooper** (ccooper@uco.edu), University of Central Oklahoma, Dept. of Mathematics and Statistics, 100 North University Drive, Edmond, OK 73034. *Trilinable Points of Curves.*

Given a curve in the Euclidean plane, any point x in the plane is said to be m-trilinable if and only if there are three points on the given curve, say x1, x2 and x3, such that d(x,x1) = d(x,x2) = d(x,x3) = m, where d(a,b) is the distance between points a and b. If there exists a number m such that x is trilinable then we say that x is a trilinable point. We examine the sets of points in the plane that comprise the trilinable points of polygons, of the conic sections, and of curves in general. Furthermore, we discuss the relationship that trilinability has with curvature. (Received September 23, 2009)

1056-Z1-2119 **Ciarán Mac an Bhaird*** (ciaranmacanbhaird@gmail.com), Department of Mathematics, National University of Ireland Maynooth, Maynooth, Co Kildare, Ireland, and **Ann O'Shea**. *The Impact of Additional Mathematics Support on Student Performance.*

We will discuss the current phenomenal growth of Mathematics Support Centres and services in the UK and Ireland. We will give a brief overview of the services and extra supports that are provided. We will also present published research which suggests that students who avail of these services perform consistently better than students of similar ability who do not avail of the services. This is particularly true of at-risk students. These students are also more likely to retain Mathematics as a subject, less likely to drop out of University because of mathematical difficulties and they feel more confident in their abilities. We will also give a brief overview of the extra online resources we are developing and providing to students to meet their specific needs. (Received September 23, 2009)

# 2010 MATHEMATICS SUBJECT CLASSIFICATION

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**00 General**
**01 History and biography**
**03 Mathematical logic and foundations**
**05 Combinatorics**
**06 Order, lattices, ordered algebraic structures**
**08 General algebraic systems**
**11 Number theory**
**12 Field theory and polynomials**
**13 Commutative rings and algebras**
**14 Algebraic geometry**
**15 Linear and multilinear algebra; matrix theory**
**16 Associative rings and algebras**
**17 Nonassociative rings and algebras**
**18 Category theory; homological algebra**
**19 *K*-theory**
**20 Group theory and generalizations**
**22 Topological groups, Lie groups**
**26 Real functions**
**28 Measure and integration**
**30 Functions of a complex variable**
**31 Potential theory**
**32 Several complex variables and analytic spaces**
**33 Special functions**
**34 Ordinary differential equations**
**35 Partial differential equations**
**37 Dynamical systems and ergodic theory**
**39 Difference and functional equations**
**40 Sequences, series, summability**
**41 Approximations and expansions**
**42 Fourier analysis**
**43 Abstract harmonic analysis**
**44 Integral transforms, operational calculus**
**45 Integral equations**
**46 Functional analysis**
**47 Operator theory**
**49 Calculus of variations and optimal control; optimization**
**51 Geometry**
**52 Convex and discrete geometry**
**53 Differential geometry**
**54 General topology**
**55 Algebraic topology**
**57 Manifolds and cell complexes**
**58 Global analysis, analysis on manifolds**
**60 Probability theory and stochastic processes**
**62 Statistics**
**65 Numerical analysis**
**68 Computer science**
**70 Mechanics of particles and systems**
**74 Mechanics of deformable solids**
**76 Fluid mechanics**
**78 Optics, electromagnetic theory**
**80 Classical thermodynamics, heat transfer**
**81 Quantum theory**
**82 Statistical mechanics, structure of matter**
**83 Relativity and gravitational theory**
**85 Astronomy and astrophysics**
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**90 Operations research, mathematical programming**
**91 Game theory, economics, social and behavioral sciences**
**92 Biology and other natural sciences**
**93 Systems theory; control**
**94 Information and communication, circuits**
**97 Mathematics education**

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ABSTRACTS

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