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* Indicates who will present the paper at the meeting.

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PAPERS PRESENTED AT MEETINGS

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

MEETING #	DATE	PLACE	ABSTRACT DEADLINE	ABSTRACT ISSUE
1046	January 5–8, 2009	Washington, DC	September 16	Vol 30, No. 1
1047	March 27–29, 2009	Urbana, IL	February 3	Vol 30, No. 2
1048	April 4–5, 2009	Raleigh, NC	February 10	Vol 30, No. 2
1049	April 25–26, 2009	San Francisco, CA	March 3	Vol 30, No. 3
1050	April 25–26, 2009	Worcester, MA	March 3	Vol 30, No. 3
1051	October 16–18, 2009	Waco, TX	August 25	Vol 30, No. 4
1052	October 24–25, 2009	University Park, PA	September 1	Vol 30, No. 4
1053	October 30–November 1, 2009	Boca Raton, FL	September 8	Vol 30, No. 4
1054	November 7–8, 2009	Riverside, CA	September 15	Vol 30, No. 4

WASHINGTON, DC, January 5–8, 2009

Abstracts of the 1046th Meeting.

00 ► General

1046-00-1 **Percy Deift*** (deift@cims.nyu.edu), 251 Mercer Street, New York, NY 10012. *Integrable Systems: A Modern View.*

The modern theory of integrable systems began with the solution of the Korteweg de Vries equation by Gardner, Greene, Kruskal and Miura in 1967. This led to the development of a variety of new mathematical techniques, and over time, and quite unexpectedly, these techniques have found applications in areas far beyond their dynamical origins. The applications include problems in algebraic geometry, numerical analysis, analytic number theory, combinatorics and random matrix theory, among many others. In the Lecture, the speaker will present some of these techniques and describe some of their applications. (Received September 15, 2008)

1046-00-301 **Sylvia R. Naples*** (sn552@bard.edu), Bard College, P.O. Box 5000, Annandale-on-Hudson, NY 12504. *An upper bound for the number of graceful labelings of a path with n edges.*

The concern of this talk is to provide an effective way to measure the rate of growth for the number of graceful labelings of a path graph with n edges, as n increases. We introduce the *graceful labeling diagram*, which we use to systematically construct graceful labelings, and develop analytical tools that exploit the structure of the diagram to compute an upper bound on the number of graceful labelings of a path. We conjecture that a path with n edges has order of $\sqrt{n}\sqrt{n-1}\cdots\sqrt{2}$ graceful labelings. (Received August 25, 2008)

1046-00-652 **A Angeleska*** (aangeles@mail.usf.edu), **N Jonoska** (jonoska@math.usf.edu) and **M Saito** (saito@math.usf.edu). *Strategies for DNA recombination using assembly graphs.*

We introduce a notion of an assembly graph that models the DNA structure during certain recombination processes. An assembly graph is a graph that consist of 4-valent rigid vertices and we study the vertex removal in these graphs, called smoothing, that models the recombination. Motivated by biological considerations, we characterize the subsets of vertices, called successful sets, whose simultaneous smoothing keep all of the gene segments on a single DNA molecule. Furthermore, we define a smoothing strategy in assembly graph as a sequence of successful sets which corresponds to a successive DNA recombination strategy. We study and characterize the "successful" strategies, i.e. the strategies that result in a complete correct DNA assembly. (Received September 09, 2008)

1046-00-760 **Ted Ashton*** (ashted@ashtonfam.org). *Don't Blow a Gasket!*

The beautiful Sierpiński Gasket (also called the Sierpiński Triangle), can be created in many different ways. In this talk, which grew out of the speaker's experience in tatting a Sierpiński triangle, we'll look at a few of those ways and how they naturally map into the fiber arts. (Received September 13, 2008)

1046-00-768 **Christiane Poeschl***, Infmath Imaging (Department of Mathematics). *Tikhonov Regularization Methods with General Data-Fit Term.* Preliminary report.

We study variational methods for the solution of inverse and ill–posed problems, which can be written in form of an operator equation

$$F(u) = v \ , \qquad u \in U, v \in V. \tag{I}$$

Originally, Tikhonov proposed a quite general setting: Only assuming that S is a functional (measuring the error between $F(u)$ and v^δ - data fit term), that $\alpha > 0$, and that R is a non-negative functional, he suggested to use a minimizer of the functional

$$S(F(u), v^\delta) + \alpha R(u) \tag{M}$$

to approximate a solution of (I). We give necessary under which we can prove well-defindness, stability, convergence and convergence rates for (M). The motivation to use more general similarity measures is to perform regularization from an information perspective, in the sense that one constrains the closeness of the data v to ist observed perturbation v^δ to satisfy an information measure rather than some distance measure associated with some function space. We discuss Bregman distances, f-divergences and the Wasserstein metric as appropriate choices for the data-fit term Sl in the general Tikhonov method. (Received September 11, 2008)

1046-00-796 **Nathaniel Alfred Persily*** (npersi@law.columbia.edu), Jerome Greene Hall, 435 West 116th Street, New York, NY 10027. *Lessons from a Court-Appointed Nonpartisan Redistricter.*

Those who have been involved in redistricting fights and resolutions have a unique perspective on the role of math, CAD and various algorithms in the redistricting process. In short, although such methods can place various constraints on the process, the ultimate decisions about which line goes where must be done by humans attempting to balance the conflicting influences of law, politics, and geography. Case studies from court-ordered plans in New York, Georgia and Maryland illustrate the difficulties in any automated form of redistricting. (Received September 11, 2008)

1046-00-867 **Arthur S Sherman*** (asherman@nih.gov), 12A South Drive, Room 4007, Bethesda, MD 20892-5621. *Opportunities in Mathematics at the National Institutes of Health.*

Biology is the least mathematical of the sciences, but advances in reductionist explanations and techniques that permit observation with unprecedented spatial and temporal resolution are opening up new opportunities for mathematicians to make important contributions.

The National Institutes of Health (NIH) presents particular opportunities and challenges for mathematicians because it is both a mission-oriented biomedical research institution and a government lab, rather than a university. The costs and benefits of this arrangement will be discussed, including the experience of having one's work evaluated by non-mathematicians, the freedom from applying for research funding or teaching, and the greater prevalence of post-doctoral fellows than graduate students. Outside grants, teaching opportunities and graduate students are available but do not play the central role that they do in the university setting. Some of the breadth of theoretical work carried out at NIH by mathematicians but also other theoreticians, such as physicists, biophysicists, statisticians and engineers will be described. (Received September 12, 2008)

1046-00-899 **Diane L. Herrmann*** (diane@math.uchicago.edu), Department of Mathematics, 5734 South University Avenue, Chicago, IL 60637. *Diaper Pattern in Needlepoint.*

Informally stated, a diaper pattern in decorative art is one that has visual diagonals in two different directions. Needlepoint canvas, because of its evenweave construction, is well suited to the creation of diaper patterns. The relationship of diaper patterns to the 17 wallpaper groups will be discussed. Many examples of needlepoint diaper patterns will be shown, including how the use of color in a single pattern can aid in identification of the symmetry. (Received September 12, 2008)

1046-00-940 **melvin henriksen*** (henriksen@hmc.edu), Department of Mathematics, 301 E. Platt Blvd, claremont, CA 91711. *Problems encountered in trying to collaborate with mathematicians in the third world.*

I have succeeded in collaborating with a number of "third world" mathematicians in countries that include Jordan, Iran, Pakistan, and India. My co-authors are talented, but only rarely are associated with famous international research institutions. Their research activities are inhibited often by heavy teaching loads, lack of useful access to fax machines, and inadequate library facilities. For example, only rarely do they have access to Math. Sci. Net. either because of cost or cost a refusal to accept communication in non-local languages. Some suggestions are made for encouraging more collaboration of this kind. (Received September 12, 2008)

1046-00-941 **Erland M Schulson*** (erland.schulson@dartmouth.edu), Tuck Drive, Hanover, NH 03755. *Sea Ice: Fracture and Frictional Sliding on Small and Large Scales.*

Arctic sea ice, whether as a floating cover or a laboratory specimen, exhibits oriented linear kinematic features when loaded to terminal failure under biaxial compressive stress states. The features mark sliding fractures. They appear, at least in some cases, to be similar to strike-slip faults within Earth's crust. The corresponding failure envelope on both the large and small scales may be described as a truncated Coulombic envelope: its slope is scale-independent, implying that the internal friction coefficient is a scale-invariant property of the material. The size of the envelope is spatially and temporally dependent, increasing with decreasing size and with increasing time. The implication is that brittle failure of the sea ice cover is characterized not by a single envelope, but by a set of nested envelopes. We interpret this behavior in terms of multi-scale fracture and frictional sliding. (Received September 12, 2008)

1046-00-972 **Thomas F. Banchoff*** (Thomas_Banchoff@brown.edu), Mathematics Department, Brown University, Providence, RI 02912. *Paperless Internet-Based Calculus Across All Levels, Updated.*

Online interactive laboratory materials and accessible communications software make it possible to teach paperless calculus courses across all levels without relying on traditional textbooks. This presentation will update earlier reports of a project supported by the Carnegie Foundation for the Advancement of Teaching, including new information on assessment and a new non-linear table of contents. (Received September 13, 2008)

1046-00-1046 **Amy F. Szczepański*** (szczepanski@math.utk.edu), Math Department, University of Tennessee, Knoxville, TN 37996. *Calculating Patterns for Knitted Surfaces.*

We present a method for calculating the pattern for knitting some geometric shapes (such as spheres and tori) that can be described as surfaces of revolution. Each of these shapes can be knit as a series of circular rounds. Writing the pattern can be reduced to a problem of determining how many stitches should be in each round and how many rounds are needed. Some approximations will need to be done, as rounds must have a whole number of stitches, and the overall pattern must have a whole number of rounds. The number of stitches in each round can be calculated by using a parameterization of the curve, rotation matrices, and approximations of arclength. We present a description of the method and software that has been written to calculate some patterns. (Received September 14, 2008)

1046-00-1125 **Kurt M. Bryan*** (kurt.bryan@rose-hulman.edu), 5500 Wabash Avenue, Terre Haute, IN 47803. *How to Thrive as a Mathematician at a Small College.*

I will discuss what it's like to work as a mathematician at a small but intense undergraduate teaching institution, and in particular the challenge of maintaining an active research program while trying to excel in the classroom under a heavy course load. Since I also spent 9 years doing mathematics in industry and government, I'll contrast the skill sets needed and give advice on how students thinking about a teaching-oriented position should prepare. (Received September 14, 2008)

1046-00-1142 **Martin Z. Bazant*** (bazant@stanford.edu), 488 Escondido Mall, Bldg. 02-500, Rm. 500A, Stanford, CA 94305. *Intercalation dynamics in rechargeable batteries.*

In spite of extensive applied research, the performance of rechargeable batteries has improved only incrementally in recent decades. Power density must improve drastically for new applications such as electric vehicles, and this will require advances in our fundamental understanding of intercalation dynamics – how ions are cycled in and out of host particles in electrodes. The current model for phase separating compounds, such as LiFePO4, assumes that the new phase replaces a diffusive "shrinking core" of the other, but recent experiments show instead the phase interface spanning the particle along crystal axes of fast diffusion. Here, we present a general phase-field theory of intercalation dynamics with two key features: (i) strong bulk anisotropy and (ii) surface reactions driven by electrochemical potential differences, including entropic and gradient contributions. The theory reproduces shrinking-core dynamics in some limits, but in the relevant regime for lithium iron phosphate, also predicts nonlinear phase-transformation waves, consistent with experimental observations. (Received September 14, 2008)

1046-00-1227 **Thorsten Markus*** (Thorsten.Markus@nasa.gov), Cryospheric Sciences Branch, Code 614.1, NASA Goddard Space Flight Center, Greenbelt, MD 20771. *Climate change and the peculiar Antarctic ocean.*

Satellite passive microwave data been used for about three decades to provide information of the polar sea ice coverage. In contrast to the Arctic sea ice, which shows a dramatic and very public reduction in sea ice cover, the trend in the Antarctic sea ice cover is slightly increasing. Precipitation is expected to increase substantially over the polar regions with increased greenhouse warming. This has important implications for the, generally weak, stability of the upper layers of the Southern Ocean as well as for the snow cover on top the sea ice. The talk will give an overview of the observed changes in the Antarctic sea ice cover and will discuss processes and mechanisms unique to the Antarctic ocean that can explain the observed asymmetry between the two polar regions. (Received September 15, 2008)

1046-00-1232 **Liming Feng*** (fenglm@illinois.edu), University of Illinois at Urbana-Champaign, 117 Transportation Building, MC-238, 104 S Mathews Ave, Urbana, IL 61801. *A Hilbert transform approach to options pricing.*

In this talk, we present a Hilbert transform approach to the pricing of various options with discrete monitoring. Option prices are represented in terms of Hilbert transforms, which can be discretized with exponentially decaying errors. The resulting discrete approximation can be implemented efficiently using the fast Fourier transform. Numerical results for options pricing in Levy models will be shown. (Received September 15, 2008)

1046-00-1301 **Kenneth Jezek*** (jezek.1@osu.edu), 1090 Carmack Road, Columbus, OH 43210. *Polar Ice Sheets: Observations and Models.*

Outlet glaciers around Greenland are thinning, accompanied by substantial acceleration of the surface velocity field. In the Antarctic, large ice streams are behaving in similarly unexpected ways, some apparently in response to changes in the subglacial hydrology. The evidence is clear that the polar ice sheets are changing, but two points remain. First, what is the dominant mechanism forcing change and second, will the changes now being observed lead to irreversible ice sheet retreat. Here, I highlight some recent observations, focusing on the glacier bed. I go onto to suggest how collaborations between the glaciology and mathematical communities could help resolve the points mentioned above. First, I present an analytic model that predicts melt beneath ice stream shear margins but which suffers from simplifying assumptions about the vertical variation of physical parameters. Second, I describe our attempt to develop a Bayesian approach for studying basal processes, which resulted in a highly sophisticated mathematical structure around the simplest possible glaciological model. Finally, I suggest how the quasi-static solution of ice dynamical solutions might be extended to include inertial forces and how that might eventually lead to better predictive modeling. (Received September 15, 2008)

1046-00-1353 **Michael S Teitelbaum*** (teitelbaum@sloan.org), 630 Fifth Avenue, New York, NY 10111. *Drivers of redistricting trends.* Preliminary report.

This presentation will discuss some of the historical, demographic, political and technological forces that have affected redistricting practices over the past 3-4 decades. (Received September 15, 2008)

1046-00-1372 **Charles R Hampton*** (Hampton@wooster.edu), Mathematics Department, The College of Wooster, Wooster, OH 44691. *Reflections upon almost 30 years involvement with redistricting.*

Arising out of a question that was posed in my mathematical modeling course about the next step after apportionment, my journey has taken me into attempts to amend the Ohio constitution, into involvement in court cases where redistricting was the central issue, and into actually drawing the district lines for California. I will discuss some of the challenges that I encountered. (Received September 15, 2008)

1046-00-1405 **Steven Strogatz*** (shs7@cornell.edu), 212 Kimball Hall, Ithaca, NY 14853. *The story of a mathematical friendship.*

In this Public Lecture, Professor Strogatz tells the story of his ongoing friendship with his high school calculus teacher, Mr. Don Joffray, as chronicled through more than 30 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 Ivy League 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 September 15, 2008)

1046-00-1412 **Richard Pildes***, NYU School of Law, New York, NY 10012. *The Law and Policy of Redistricting.* Preliminary report.

This talk will explore the relationship between social science, law, and policy in the area of the design of election districts. (Received September 15, 2008)

1046-00-1413 **Hari P Adhikari*** (hpadhika@mail.usf.edu), 4202 E Fowler Ave, PHY 114, Tampa, FL 33620. *American Option Pricing under Stochastic Volatility.*

In this paper, we price the American option where the underlying asset follows the diffusion process and the stochastically varying volatility parameter follows the mean-reverting process.

In this method, the free boundary system for American option is converted into a fixed boundary value problem with free boundary curve incorporated into the coefficients of new PDE. Then using integral transform (Fourier/Laplace), PDE is converted into ODE which can be readily solved .The solution is transformed back to the original space which explicitly contains the free boundary curve. The free boundary curve is numerically solved and substituted in the above solution giving us the solution for the American option under stochastic volatility.

We shall compare the price solutions of American options by this approach and by some other methods, in terms of the accuracy, efficiency, and robustness. (Received September 15, 2008)

1046-00-1650 **Xiaomei Ji*** (xji@ams.sunysb.edu), Dept. of Applied Mathematics & Statistics, Stony Brook University, Stony Brook, NY 11794-3600. *An optimal order error estimate of a linear finite element method for smooth solutions of 2D systems of conservation laws.*

We consider approximating smooth solutions of systems of nonlinear conservation laws by a linear finite element method with uniform mesh in two spatial dimensions, where the time discretization is carried out by a second order explicit Runge-Kutta method. An optimal error estimate $O(h^2)$ in L^2-norm for continuous linear finite elements is obtained under the CFL condition $\Delta t \leq Ch^{\frac{4}{3}}$, where h and Δt are the spatial meshsize and the time step, respectively, and the positive constant C is independent of h and Δt. (Received September 16, 2008)

1046-00-1672 **David Gardner** (david.gardner@students.olin.edu), **Yiyang Li** (yiyang.li@students.olin.edu) and **Benjamin Small*** (benjamin.small@students.olin.edu), 1000 Olin Way, Needham, MA 02492. *Nonlinear Dynamics of a Simple Microvascular Network.* Preliminary report.

Blood flow through microvascular networks has been shown to change, oscillate, and even reverse direction without biological control. In order to study this phenomenon, we investigate a model of blood flow through small vessels. Blood flowing through small vessels exhibits rheological properties such as the Fåhræus-Lindqvist effect, which describes the viscosity of blood, and plasma skimming, which governs the separation of red blood cells at diverging nodes. We define a node to be the intersection of exactly three blood vessels, and a network to be the union of two or more nodes. To help understand large complex networks consisting of hundreds of vessels, we begin by studying a simple three node network. Using a variety of analytical and computational tools, we develop methods to find the equilibrium solutions that a given configuration of the three node network can support and the stability of each of these solutions. Our results will be used to design *in vitro* experiments. (Received September 16, 2008)

1046-00-1736 **Mac Hyman*** (hyman@lanl.gov), Los Alamos National Laboratory, Los Alamos, NM 87545. *Good Choices for Great Careers in the Mathematical Sciences.*

The choices students and scientists make early in their careers will impact them for a lifetime. I will use the experiences of scientists who have had great careers to identify universal distinguishing traits of good career choices that can guild decisions in education, choice of profession, and job opportunities to increase your chances of having a great career with long-term sustained accomplishments.

Recently, I began tracking the careers our past student interns and realized that the scientists with great careers weren't necessarily the top students, and that some of the most brilliant students now had some of the most oh-hum careers.

I will describe how choices made by the scientists with great careers were based on following their passion, building their talents into a strength supporting their profession, and how they identified a supportive engaging work environment. I will describe simple principles that can help guide your choices, in school and in picking the right job leading to a rewarding career and more meaningful life.

The topic is important because, so far as I can tell, life is not a trial run - we have one shot to get it right. The choices you are making right now to planning your career will impact your for a lifetime. (Received September 16, 2008)

01 ► History and biography

1046-01-27 **saeed seyed agha banihashemi*** (ihusaied2001@yahoo.com), no-20-gyte St- vafa manesh st.Lavizan, tehran, Iran. *How history of mathematics can help education of mathematics.* Preliminary report.

We know that all over the world mathematics is a difficult subject .I

Last fifty years ago different tools are to be used to understanding Mathematics .for example mathematical software likes mathematica, mathcad ,and so on, one of the helpful tools are history of mathematics Which during last little decay become very important. With history of mathematics teacher can make change style in teaching When is necessary. With history of mathematics student can Understand that science is work of all civilization. In this article we Show how history of mathematics can help teacher and student in maths subject. (Received June 10, 2008)

1046-01-33 **Steven H. Weintraub*** (shw2@lehigh.edu), Dept. of Mathematics, Lehigh University, Bethlehem, PA. *Insights into Cayley's work on the quintic.*

The Lehigh University library has a collection of 40 letters written from Arthur Cayley to Robert Harley between 1859 and 1863, and an unpublished manuscript “A Memoir on the Quintic Equation” that Cayley was working on at the time of his death in 1895. Examination of this material, which is available online at as part of the library's digital archive at http://digital.lib.lehigh.edu/remain/con/cayley.html, gives insights into the working relation between Cayley and Harley as they attacked the quintic from an invariant-theoretic point of view, and into Cayley's lifelong interest in the quintic. (Received June 30, 2008)

1046-01-166 **Lawrence S. Braden*** (lbraden@sps.edu), Lawrence S. Braden, St. Paul's School, Concord, NH 03301. *F dot ds...Simple Calculus, Deep Physics.* Preliminary report.

See why Conservation of Momentum is a theorem, not an axiom (Feynman, ”The Nature of physical Law”). And why Einstein's ubiquitous ”E equals mc squared” is not really the heart of nuclear weapons, but the work integral (Serber, ”The Los Alamos Primer”.)

A simple and direct derivation of Einstein's formula will be provided as a handout.) (Received August 08, 2008)

1046-01-238 **Jiang-Ping Jeff Chen*** (jjchen@stcloudstate.edu), ECC 226, Dept. of Math, SCSU, 720 4th Ave. S., St. Cloud, MN 56301. *From Proofs to Suanli (Mathematical Principles) in Late Imperial China.*

Traditional Chinese mathematics treatises did not have proofs. Even after proof-writing was introduced to China in the translation of Euclid's Elements (Jihe yuanben) writing proofs and citing axioms never became a standard practice in mathematical treatises in 17th- and 18th-century China. Instead, the discussion or explanation of suanli (mathematical principles) replaced the proof under the heading, lun (discussion), where the proof should have been. Scholars sometimes evoked suanli to support the correctness of their claims. It seems that to understand mathematics reasoning in late imperial China, examining the concept of suanli might be more appropriate than trying to determine whether the discussions qualified as proofs. In the paper, I attempt to explore one aspect of suanli in early to mid-Qing through various scholars' explanations of Shijiao fa (the method of sagittae difference). Specifically I will examine the explanations of how two mathematicians employed this method. I will investigate one characteristic of suanli by showing that one scholar's revision of the other's explanation on this method amounts to systemizing various ad hoc procedures for problems of similar nature and elucidating them using one single principle. (Received August 21, 2008)

1046-01-242 **Yibao Xu*** (yxu@bmcc.cuny.edu), 199 Chambers Street, New York, NY 10007. *George Sarton (1884-1956) and Chinese Mathematics.* Preliminary report.

In his monumental work, Introduction to the History of Science (3 vols. in 5, 1927-1948), George Sarton provides an account not only of Western science, but also that of Islam, India, and China. Among Chinese sciences from ancient times down to the Renaissance, Chinese mathematics was Sarton's major focus.

Comparing the proofread version of the Introduction to History of Science, preserved in the Harvard University Archives, with its published one, and drawing valuable information from Sarton's correspondence kept both at the Houghton Library of Harvard University and at the Henry W. and Albert A. Berg Collection of English and American Literature of the New York Public Library, this paper tries to assess and reconstruct how his account of Chinese mathematics was made. (Received August 21, 2008)

1046-01-282 **Thomas Drucker*** (druckert@uww.edu), Dept. of Math. and Comp. Sciences, University of Wisconsin–Whitewater, Whitewater, WI 53190. *Did Geometry Need Saving From Bourbaki?* Preliminary report.

Siobhan Roberts' biography of H.S.M. Coxeter has in its subtitle the phrase 'The Man Who Saved Geometry'. The author suggests that Bourbaki was the threat from which geometry was most in need of saving. In particular, negative statements from Coxeter about Bourbaki are used to suggest that he played a heroic role in bringing down the Bourbaki monster. This talk makes two claims. First, Coxeter was taking aim at something of a travesty of Bourbaki, although it was not a travesty entirely without foundation. Secondly, the failure of Bourbaki, as Leo Corry suggests in his history of algebra and mathematical structures, can be attributed to internal difficulties with the Bourbakist program. Coxeter's accomplishments do not require being set against Bourbaki in order to be admired. (Received August 25, 2008)

1046-01-287 **Peggy Aldrich Kidwell*** (kidwellp@si.edu), MRC631, NMAH, Smithsonian Institution, P.O. Box 37012, Washington, DC 20013-7012. *Computing Devices, Mathematics Education and Mathematics - Sexton's Omnimetre in Its Time.*

In 1899, Albert Sexton, a Philadelphia mechanical engineer, received the John Scott Medal of the Franklin Institute for his invention of the Omnimetre, a circular slide rule designed to carry out all the common operations of arithmetic and trigonometry, except addition and subtraction. At the suggestion of a Belgian-born user of the instrument, it was inscribed: "NUMERI MUNDUM REGUNT." In part because of instruments like the omnimetre, numbers increasingly ruled the practical world of the late nineteenth and early twentieth century United States. This changed not only engineering, but mathematics education and mathematics itself. (Received August 25, 2008)

1046-01-299 **Glen R Van Brummelen*** (gvb@questu.ca), Quest University, 3200 University Blvd, Squamish, BC V8B 0N8, Canada. *Trigonometry on the Edge: Interpolation in Ancient and Medieval Astronomy.*

As odd as it sounds, interpolation was a branch of trigonometry during the medieval period in India and Islam. It led a peculiar life on the fringes of mathematical astronomy, a mathematical helpmate, but at least in Islam, an over-shadowed sister to geometry. Some of the best scientists (al-Biruni and al-Kashi among them) made serious mistakes when trying to generate second-order schemes, but others (including Brahmagupta and Ibn Yunus) constructed conceptual mechanisms that led to equivalents of modern formulas. We shall examine how several authors conceived of their methods, and what they thought of them in relation to the entire discipline. (Received August 25, 2008)

1046-01-345 **Maria Sol de Mora*** (demora@leibnizsociedad.org), Berlinés, 50, 1, 08022 Barcelona, Spain. *LEIBNIZ AND THE TWO PROBLEMS OF MÉRÉ.*

We shall try to show here the encounters and disencounters (mainly the second) of Leibniz and the renowned Chevalier de Méré, especially during the stay of Leibniz in Paris and in the years immediately after, when Leibniz was interested in the mathematical aspects of the Theory of Probability. We shall also try to establish the contacts of Leibniz with Pascal's work in the field of probability theory, and the resolution of the two problems proposed by Méré to Pascal, and referred to by Pascal in his letter to Fermat of July 1654. The concern of Leibniz with the questions of contingency is well known and it goes back to his youth. At 1665 he submitted the Disputatio juridica de conditionibus, where he used numbers to represent what he called "degrees of probability"; he was only 19. Before a contingent set of circumstances, we have to come to a decision not totally justified by the Art of Demonstration or of Judgment, but pertaining to the Art of Conjecturing. (Received August 27, 2008)

1046-01-356 **Kathryn James*** (kathryn.james@yale.edu), Beinecke Library, P.O. Box 208240, New Haven, CT 06520-8240. *Mrs. Bean's Young Ladies: Mathematics Education in Early Modern England.*

Textbooks, student notebooks, and household recipe and account books are among the many different types of sources showing how mathematics was taught and used in popular culture in 17th and 18th-century England. Fewer explicit sources exist to show how women were taught mathematics in the early modern period. This paper looks at two late 17th-century student notebooks–one in the collections of the Folger Shakespeare Library, and one in those of Yale's Beinecke Library–kept by two young girls who studied arithmetic and calligraphy with their teacher, Mrs. Elizabeth Bean. The notebooks allow insight into two areas: first, how mathematics was approached as one facet of a more general education and, second, how arithmetic was situated within a broader commercial and popular cultural context. A comparison of these notebooks with other student notebooks and printed textbooks of the period allows us to begin to characterize how mathematics was taught in the early modern period, and how it might have been inflected for different audiences. (Received August 27, 2008)

1046-01-367 **Craig Fraser*** (cfraser@chass.utoronto.ca), Inst. Hist. Phil. Sci. Tech., University of Toronto, Toronto, Ontario M5S 1K7, Canada. *The Prehistory of the Cauchy-Riemann Equations.* Preliminary report.

The Cauchy-Riemann equations connect the real and imaginary parts of an analytic function. $f(z) = p(x, y) + iq(x, y)$ is an analytic function on a given domain if and only if the Cauchy-Riemann equations $\frac{\partial p}{\partial x} = \frac{\partial q}{\partial y}, \frac{\partial p}{\partial y} = -\frac{\partial q}{\partial x}$ are satisfied there. Although the equations are named after Augustin Cauchy (1789-1857) and Bernhard Riemann (1826-1866), they first appeared in 1752 in a book by Jean d'Alembert (1717-1783) on fluid dynamics. The paper traces the emergence of the equations and their subsequent development in the period before Cauchy. This history requires examination of the early theory of partial differential equations, a subject pioneered by Leonhard Euler (1707-1783) and d'Alembert from a few principles and methods of solution. The prehistory of the Cauchy-Riemann equations provides insight into the core technical ideas that would later develop into complex analysis. (Received August 28, 2008)

1046-01-369 **Adrian Rice*** (arice4@rmc.edu), Department of Mathematics, Randolph-Macon College, Ashland, VA 23005. *Elliptic Functions via Invariant Theory: Cayley's partial anticipation of the Weierstrass ℘-function.*

Although perhaps best remembered today for his contributions to matrix algebra and group theory, Arthur Cayley did not limit his research to these areas alone. One of his prime interests was the subject of elliptic functions, among the most vibrant areas of mathematics in the 19th century. His publications on this topic spanned over half a century and included a little known but interesting anticipation of an identity later made famous by Weierstrass. But what is particularly pleasing about Cayley's derivation of this identity is that it relied totally on his use of invariant theory, a subject that not only was his major area of research, but which also seems, on the face of it, to have little in common with the theory of elliptic functions. In this paper, we compare Cayley's derivation to the standard Weierstrassian approach, and discuss reasons for the obscurity of the former compared to the relative fame of the latter. (Received August 28, 2008)

1046-01-378 **Donald G Babbitt** and **Judith R Goodstein*** (jrg@caltech.edu), California Institute of California, Institute Archives, MS 015A-74, Pasadena, CA 91125. *Grading the Greats: What G. Castelnuovo and F. Severi thought of one another in the 1930s.* Preliminary report.

Guido Castelnuovo and Francesco Severi were two of most important figures in the history of Italian algebraic geometry who both carried on a fascinating correspondence with their more junior colleague, Beniamino Segre. The correspondence to Segre has fortunately been preserved and offers an interesting socio-mathematical apercu into Italian algebraic geometry. Among this correspondence, there is a 1932 letter from Severi to Segre that offers the former's opinion of who was overrated and who was underrated among the major figures, including Castelnuovo, in (not just Italian) algebraic geometry from 1850 up to the early 20th century. He also gives an unsurprisingly immodest appraisal of his own contributions. There is also a 1938 letter from Castelnuovo to Segre that contains a paragraph assessing Severi's contributions to algebraic geometry focusing mainly on the first, probably most prolific, years of his research career. Our talk will discuss these two letters together with some background on the temperament and politics of these two personalities, who could not have been more different. (Received August 28, 2008)

1046-01-384 **Roger L. Cooke*** (rogercooke@burlingtontelecom.net), 500 South Union Street, Burlington, VT 05401-4808. *The Polish-American mathematician Joseph Perott.* Preliminary report.

The life of Joseph Perott (1854–1924), one of the minor mathematicians of the late nineteenth century, helps to fill in a few mathematical and historical details from this period in Europe and the United States. Born in Saint Petersburg of a Polish father and Russian mother, in later life he told people that he had a French father and a Polish mother. In the 1880s, he interacted with Sof'ya Kovalevskaya (1850–1891) in both mathematical and literary activities. At the end of that decade, he emigrated to the United States and in 1890 became a docent at Clark University, where he remained for the second half of his life. (Received August 29, 2008)

1046-01-413 **Florence D Fasanelli*** (ffasanel@aaas.org), AAAS, 1200 New York Ave. NW, Washington, DC 20005. *Andrew Ellicott: mathematician, surveyor, teacher.* Preliminary report.

Since ancient times, conquerors have sent mathematicians to survey their new territory. Andrew Ellicott (1754-1820) had a profound impact on the shape of this country, establishing boundaries of states and cities as well as its international boundaries both north and south. In 1791, he surveyed the territory now known as the District of Columbia and a year later produced the first engraved map of the future city developed from plans of Pierre L'Enfant. In 1796, he surveyed the international border between the U.S. and Spanish territories in Florida under the San Lorenzo Treaty. In 1817, he was appointed astronomer for the United States establishing the boundary between the US and Canada, concluding the War of 1812.

As a teacher his most famous student was Meriwether Lewis who needed field instruction before Lewis' great expedition to the west. In 1813, he was appointed by President Monroe as a professor of mathematics at the Military Academy at West Point where he was among the first in the country who taught a class in calculus. (Received September 01, 2008)

1046-01-447 **Victor J. Katz*** (vkatz@udc.edu), 841 Bromley St., Silver Spring, MD 20902. *On the History of Algebra.* Preliminary report.

The term "algebra" up through the nineteenth century meant the "solving of equations," that is, the determination of an unknown quantity or quantities from a relationship of equality among those quantities and various known quantities. In this talk, we will consider the history of algebra through the nineteenth century, at least in the West, in terms of three distinct stages, the geometric stage, the static equation-solving stage, and finally the dynamic function stage. Examples will be given from Mesopotamia, Greece, Islam, and early modern Europe. We will conclude with a brief look at algebra in India and China to see how they fit this model. (Received September 03, 2008)

1046-01-506 **William T Archibald*** (tarchi@sfu.ca), Dept of Mathematics, Simon Fraser University, Burnaby, BC V5A1S6, Canada, and **Rossana Tazzioli**. *Integral Equations: a "Revolution" in Mathematics in the early 20th Century?*

When, in 1900, Ivar Fredholm introduced his method for reformulating boundary-value problems as integral equations, it provoked a flood of interest internationally. On the one hand, it promised a theoretical approach that would provide for the first time a unifed theory of partial differential equations, what Hilbert termed a "unifed approach to Schwingungslehre". On the other, it seemed to give a means of actually solving boundary-value problems that were of physical interest, most notably in elasticity and fluid mechanics. An international stampede of activity at the research and teaching levels followed, reminiscent of the surge of interest in catastrophe theory in the 1960s and 1970s, or in fractals and chaos somewhat later. In this paper we look at the reasons for this "fad", and discuss what distinguishes really finding mathematical gold from a flash in the pan. (Received September 05, 2008)

1046-01-525 **Renaud G. Chorlay*** (renaud-chorlay@noos.fr), Universite Denis Diderot PARIS VII, case courier 7064, 2 place jussieu, 75251 Paris Cedex 05, France. *What is at stake in Weierstrass' criticism of Riemann's function theory ?*

The comparison between the theory of complex functions a la Riemann and a la Weierstrass has been a standard topic since the end of the 19th century. However, what exactly is at stake remains, to some extent, unclear; we think it calls for both epistemological and historical work. We shall first stress elements which are common to both mathematicians, such as the rejection of brute calculation, the conception of regular functions, and the use of singularities. We will also use the example of Poincare's work to show that, long before Weyl's "Idea of a Riemann surface", some mathematicians had successfully devised a mixed approach. This should help pinpoint more precisely where the differences lie. We will also document the ways in which these differences were described by late 19th century mathematicians : discovery vs proof, intuition vs rigor, geometry vs arithmetic, transcendental vs algebraic, global vs local. Analyzing the meaning and use of these pairs can contribute to the historical epistemology (in the sense of Daston) of some standard categories in the mathematical discourse. From a more philosophical viewpoint, it can provide non-standard case studies for the ongoing debates on issues such as purity of methods, choice of "proper" setting, and geometric thinking. (Received September 06, 2008)

1046-01-538 **Nancy S. Hall*** (nhall@udel.edu), University of Delaware Academic Center, P. O. Box 627, Georgetown, DE 19947. *What Led Ronald Fisher to the Concept of Randomization? A Re-Examination.* Preliminary report.

In his 1925 book Statistical Methods for Research Workers, Ronald Fisher first published the requirement of randomization in experimental design:- elimination of bias derived from the experimental material or from the researcher- possibility of a valid test of significance.No where in Fisher's known correspondence, notes or publications is anything discussing his development of the concept. I have argued, based on Fisher's correspondence with Student (William Sealy Gosset) that this concept came primarily from the mathematics of small samples. Student, a master brewer for Guinness, often had to deal with samples as small as four. But Fisher was also an advisor to the Society for Psychical Research. The Society, founded in 1882, had the same problem as in many other fields of research: when are results significant and when are they merely due to chance? Fisher published three papers discussing the guessing of playing cards. The first of these papers appeared in print in 1924. Both Ian Hacking and Fisher's biographer, Joan Fisher Box, have written that Fisher did not believe in either telepathy or clairvoyance. They have both concluded, apparently based only upon this, that Fisher was not influenced by his work with the Society for Psychical Research. A closer look is needed. (Received September 07, 2008)

1046-01-557 **Nathan Sidoli***, nathan.sidoli@utoronto.ca. *Drawing diagrams and making arguments in Greek mathematics.*

Almost all of our evidence for Greek mathematical activity is derived from medieval manuscripts written many centuries after the original composition of the treatises they purport to transmit. Moreover, the activity of manuscript transmission was essentially scholastic and literary and may have often been far removed from the activities through which ancient mathematics was produced and taught. Indeed, in the ancient texts there is evidence for different types of mathematical activity such as oral presentation, material practices of problem solving and clearly literary practices, such calculation by tables. In this talk, I offer some speculations about Greek mathematics as a human activity and use these ideas in turn to explain some of the distinctive features of the Greek mathematical texts, as they have come down to us. (Received September 08, 2008)

1046-01-562 **Sanford L Segal*** (ssgl@math.rochester.edu), Dept. of Mathematics, University of Rochester, Rochester, NY 14627. *The real inventor of the computer.* Preliminary report.

It is often claimed that the inventor of modern-day computation was the brilliant John von Neumann. However, that title belongs not to von Neumann, but to Konrad Zuse, who invented modern computation in Germany during World War II, but received little military or other support. He was a civil engineer who was annoyed by the lengthy computations required by his profession. In fact his first machines were constructed in his parents' home. Zuse survived the war, and had a substantial career afterwards. The war was the reason his contributions were not known in the US or Britain. He died in 1995. (Received September 08, 2008)

1046-01-609 **Robin Wilson*** (r.j.wilson@open.ac.uk), Department of the Mathematical Sciences, Milton Keynes, MK7 6AA, England. *The early years of Gresham College, London.*

The Gresham Chair of Geometry is the oldest mathematics professorship in England, being founded in 1596, after Sir Thomas Gresham left instructions in his will for the founding of a college at which free lectures in seven subjects would be given to interested members of the general public. Four hundred years on, this is still the case.

This talk outlines the first one hundred years of the college, and describes the geometry professors during this period, including Henry Briggs (co-inventor of logarithms), Isaac Barrow (first Lucasian professor in Cambridge) and Robert Hooke. It also outlines the founding of the Royal Society, which was intimately associated with Gresham College, and was based there, for the its first fifty years. (Received September 09, 2008)

1046-01-639 **Duncan J. Melville*** (dmelville@stlawu.edu), Dept of Mathematics, St. Lawrence University, Canton, NY 13617. *The Problem of Word Problems.* Preliminary report.

Old Babylonian mathematics is widely known for its abundant word problems. The deciphering of these texts and the uncovering of the range and depth of the word problems led to a significant re-evaluation of the early history of mathematics during the twentieth century. Their use in an educational context was taken for granted. More recently, detailed work on reconstructing the course of study in Old Babylonian scribal education has raised questions about when and how these texts were used. Here, I will discuss attempts to locate mathematical problem texts and their functions within the wider scribal corpus. (Received September 09, 2008)

1046-01-649 **Mohammad K. Azarian*** (azarian@evansville.edu), University of Evansville, Mathematics Department, Evansville, IN 47722. *Al-Risala al-Muhitiyya II ("The Treatise on the Circumference").*

We will continue our discussion of the January 2008 meeting in San Diego of al-Risala al-muhitiyya. In particular, we will talk about the errors of Abu'l-Wafa al-Buzjani and Abu Rayhan al-Biruni that al-Kashi discussed in the introduction of al-Risala al-muhitiyya. Also, we will comment on Paul L. Luckey's German translation of this risala. (Received September 09, 2008)

1046-01-688 **Laura E. Turner*** (SILT@ivs.au.dk), Department of Science Studies, University of Aarhus, C.F. Møllers Allé, bygn. 1110, 8000 Aarhus C, Denmark. *Teacher and Mentor: Gösta Mittag-Leffler's influence on the Swedish mathematical community through his role as professor at Stockholms högskola.* Preliminary report.

The Swedish mathematician Gösta Mittag-Leffler had many characteristics of an "influential person": he was politically active, wealthy, and passionate about his studies. Furthermore, he was a successful mathematician and in touch with the upper echelon of the late 19th- to early 20th-century European mathematical community. Though in recent years he has been discussed as an organizer of mathematics, a journal editor, and to some extent a mathematician, less attention has been paid to his role as a teacher and relatively little has been done to investigate his impact on mathematics through this area of his career. This paper thus aims to present a case study in which Mittag-Leffler appears as a professor and mentor for two of his first students at Stockholms högskola, Ivar Bendixson (1861-1935) and Edvard Phragmén (1863-1937), and to discuss his impact on the content and diffusion of their early mathematical research. More generally, their early publications, concerning Prussian mathematics with which Mittag-Leffler was well-acquainted, combined with lecture notes and correspondence provide a window through which to observe Mittag-Leffler's teaching at the högskola and the nature of the mathematics he instilled within a new generation of Swedish mathematicians. (Received September 10, 2008)

1046-01-690 **Kim Plofker*** (kim_plofker@alumni.brown.edu), Department of Mathematics, Union College, Schenectady, NY 12308. *A medieval Muslim mathematician looks at Indian arithmetic: Al-Biruni's treatise on Sanskrit rules of proportion.*

Rules on various kinds of proportions, from the familiar "Rule of Three" on up as far as the "Rule of Eleven", formed an important part of Sanskrit arithmetic texts in medieval India. The Central Asian mathematician al-Biruni, who studied Sanskrit mathematics and astronomy in northern India in the early eleventh century, was sufficiently intrigued by these rules to write an Arabic treatise comparing them to Euclidean notions of ratio: the *Maqāla fī rāshikāt al-Hind*, or "Treatise on Proportions of the Indians". We examine the way al-Biruni treated his subject, why he thought it was important, and what its consequences were for the interaction of Indian and Islamic mathematics. (Received September 10, 2008)

1046-01-696 **William Lindgren*** (william.lindgren@sru.edu), Department of Mathematics, Slippery Rock University, Slippery Rock, PA 16057, and **Joan Richards**, History Department, Brown University, Providence, RI 02912. *Edwin Abbott and the mathematics of Flatland.*

Although Edwin Abbott was no more a mathematician than the narrator of his best-known book, he did have a number of interesting connections to the British mathematical community. We consider the mathematical education of Abbott and two friends, Howard Candler and William Steadman Aldis, at the City of London School and at the University of Cambridge. We discuss his tenure as Headmaster including his position on the teaching of Euclid and his influence on several students who became notable mathematicians. Finally, we consider the historical significance of the ancient Greek mathematics in *Flatland*. (Received September 10, 2008)

1046-01-719 **Jacqueline Feke*** (jackie.feke@utoronto.ca), Toronto, ON , Canada. *Ptolemy's Indisputable Mathematical Tools.*

In both the Harmonics and the Almagest, Ptolemy describes arithmetic and geometry as indisputable. Their kinds of proof proceed by indisputable methods, and they serve as indisputable tools for at least two branches of mathematics: harmonics and astronomy. These branches of mathematics, harmonics and astronomy, each rely on a single indisputable mathematical tool. Harmonics utilizes arithmetic ratios, and the eccentric and epicyclic spheres that Ptolemy posits in his astronomical hypotheses derive from geometry. Despite their use of indisputable tools, Ptolemy's hypotheses of harmonics and astronomy are not equal in their claims to truth. The text of the Harmonics indicates that Ptolemy believed in the truth and precision of his harmonic hypotheses, but the Almagest reveals that, while Ptolemy believed that his astronomical hypotheses were as precise as possible, he considered only certain aspects of the hypotheses to be true. In this paper, I argue that the crucial dissimilarity between Ptolemy's harmonics and astronomy that differentiates their claims to truth is exemplified by their relationship to the indisputable mathematical tools, arithmetic and geometry. (Received September 10, 2008)

1046-01-720 **Robert E. Bradley*** (bradley@adelphi.edu), Adelphi University, Dept. of Mathematics & Computer Science, Garden City, NY 11530. *Saving the phenomena: limits from Maclaurin to Cauchy.* Preliminary report.

The modern definition of the limit and its success in providing a foundation for calculus can be traced to Cauchy, beginning with his *Cours d'analyse* of 1821. I will argue that we may interpret Cauchy's *Cours* as being as much concerned with preserving contemporary practices in analysis as with bringing about a foundational revolution. In this sense, at least, there is a parallel to be drawn with Maclaurin's 1742 *Treatise of Fluxions*, in which the limit concept is also employed. I will examine this connecting thread in these two works. (Received September 10, 2008)

1046-01-739 **Toke Lindegaard Knudsen*** (knudsetl@oneonta.edu), Department of Mathematics, State University of New York, College at Oneonta, Oneonta, NY 13820. *Mathematics in medieval India: The* Bījagaṇita *of Jñānarāja.*

Among the unpublished and unstudied mathematical works of medieval India is the *Bījagaṇita* of Jñānarāja, who flourished in what is now the state of Maharashtra around 1500 CE. While the treatise is the third and last part of the *Siddhāntasundara*, a larger work on astronomy and cosmology, it treats mathematics as a topic in its own right. The presentation will focus on mathematical results from medieval India based on a study of the *Bījagaṇita*. (Received September 10, 2008)

1046-01-753 **Jeff A Suzuki*** (jeff_suzuki@yahoo.com), 2900 Bedford Ave., Brooklyn, NY 11210. *A History of College Algebra in the United States During the Nineteenth Century.*

During the course of the nineteenth century, college algebra evolved from a rather haphazard collection of topics to a course not too dissimilar from that taught at many institutions today. We will examine the rise and fall of several topics, including factoring, systems of multilinear equations, the theory of equations, numerical methods of solution, various symbolic operations, and solving logarithmic and exponential expressions. (Received September 10, 2008)

1046-01-769 **C Edward Sandifer*** (sandifere@wcsu.edu), C Edward Sandifer, Department of Mathematics, Western Connecticut State University, Danbury, CT 06810. *Euler, Lagrange and Cauchy: Three perspectives on the "Euler Identity".*

The transformation in the foundation of analysis between Euler's 1748 classic *Introductio in analysin infinitorum* and Cauchy's 1821 work *Cours d'analyse* is illustrated by their different treatments of the Euler identity, $e^{i\pi} = -1$. We describe those proofs, along with that of Lagrange, and show how their different approaches reflect the underlying transformation in analysis. (Received September 11, 2008)

1046-01-802 **Colin McLarty***, colin.mclarty@case.edu. *Hilbert and the origin myth of modern mathematics.*

One small puzzling proof by David Hilbert in 1888 became the paradigm of modern axiomatic mathematics, and Hilbert knew its importance. With time the affair grew into an origin myth, a titanomachy where new gods defeat the old, and specifically Hilbert defeats one Professor Paul Gordan who is known today for rejecting Hilbert's proof and calling it "not Mathematics but Theology!" In fact Hilbert found his proof in conversation with this very Prof. Gordan and Gordan supported it from the start. The talk traces the growth of the legend over 60 years from the original proof until the story was canonized in no less than three versions by Eric Temple Bell. (Received September 11, 2008)

1046-01-1126 **Daniel S. Alexander*** (daniel.alexander@drake.edu), Department of Mathematics & Computer Sciences, Drake University, 2507 University Avenue, Des Moines, IA 50311. *The Center Problem in Complex Dynamics, 1913-1942.* Preliminary report.

The problem of determining the behavior iterates of a complex rational function f near an irrationally indifferent fixed point λ was one of the more intractable problems in complex dynamics during the first half of the 20th Century.

If iteration could be linearized, that is, if a convergent solution B to the Schróder functional equation $B \circ f = f'(\lambda)B$ existed, then a center was said to exist, and iteration near the fixed point would be conformally equivalent to an irrational rotation of a disc.

Determining whether or not a solution existed if f was of degree two or greater proved quite difficult, however, and the problem resisted the best attempts of several mathematicians. Indeed, in 1919 Gaston Julia claimed to have proved that aside from the linear case centers did not exist, a claim he later withdrew.

Until Carl Ludwig Siegel demonstrated the existence of centers in 1942 progress was either in the negative—determining conditions under which the centers did not exist—or the conditional: Assume a center exists and explore the consequences. This presentation will survey the efforts of several mathematicians to confront this problem, among them, Siegel, Julia, Pierre Fatou, George Pfeiffer and Hubert Cremer. (Received September 14, 2008)

1046-01-1270 **Mohammad Moazzam*** (mxmoazzam@salisbury.edu), 1101 Camden Ave., Dept of Math & Computer Science, Salisbury, MD 21801. *Mathematician or Physician?* Preliminary report.

Many people know about Avicenne's medical work include in his book "Al-shafa". Although they know about Avicenne's medical contributions, few realize that he was quite a mathematician. This Persian mathematician's contributions to mathematics (980-1037 A.D.) were significant. His work in arithmetic, algebra and geometry contains much mathematical content to enhance mathematics courses for undergraduate students. In this talk some of Aviceene's mathematics will be examined, and suggestions for inclusion into college courses will be offered. (Received September 15, 2008)

1046-01-1437 **George E. Smith*** (george.smith@tufts.edu), Department of Philosophy, Tufts University, Medford, MA 02155. *The Mathematics in Newton's Principia Mathematica.*

Did Newton employ the calculus in developing his *Principia*? This frequently asked question is unfortunate not merely because it has no simple "yes-no" answer, but even more so because it draws attention away from the extraordinary range of mathematical techniques that he did employ in that book. The talk will first survey the range of techniques he did employ, in the process explaining why the question whether he employed the calculus has no "yes-no" answer. It will then consider a couple of the many problems peculiar to the physics of the Principia that forced Newton to devise novel mathematical techniques that reach far beyond any of those people usually have in mind when they ask whether he did or did not employ the calculus in his physics. (Received September 15, 2008)

1046-01-1566 **Christine Phili*** (xfili@math.ntua.gr), Iroon Polytexniou 9, Zografou, 15780 Athens, Greece. *Ioannis Carandinos and the Ionian Academy.* Preliminary report.

Ioannis Carandinos and the Ionian Academy

Carandinos, from Cephalonia was the man, who in the beginning of the XIXth century, introduced modern mathematics in Greece with his teaching and with his important translations. Rector, professor, research worker and translator these are the four facets of Carandinos personality. First Rector of Ionian Academy (British period), he showed evidence of his efficacious administrative activities during his mandate (1824-1832). From his teaching was created the first kernel of mathematicians in Greece. Attracted by infinitesimal analysis he contributed to its rigorous foundation with his teatise. Research on the nature of differential calculus. Tireless translator he offered to the nation some French contemporary mathematical books, of high level, but at the same time accessible to Greeks. He also created modern mathematical terminology in Greek. Gifted with a will of iron, he surmounted all material obstacles opening new perspectives for Greece. The new notions of: differential quotient, integral, function, limit, derivative etc. were transplanted in Greece and almost all mathematical culture of the XVIIIth century took roots in the Ionian islands. (Received September 16, 2008)

1046-01-1574 **Charlotte K Simmons*** (cksimmons@ucok.edu), 100 N. University Drive, Edmond, OK 73034. *Boole and Hamilton: An Unanswered Question.* Preliminary report.

Sir William Rowan Hamilton and George Boole are regarded as two of the greatest nineteenth century algebraists, and rightly so, as their work helped lay the foundations for abstract algebra. Though from very different backgrounds, they actually had much in common beyond mathematics. Both of their careers were significantly impacted by their early education, their religious beliefs, and by what they believed to be their mission in life. The similarities in their philosophical views and in certain personality traits that contributed significantly to their success are discussed at length in a recent paper. In spite of these similarities and the fact that they lived in close proximity for many years, Hamilton and Boole never had any significant interaction with each other. As MacHale puts it, "One of the greatest mysteries surrounding Boole's life in Ireland is undoubtedly his lack of contact with the man who was Ireland's greatest mathematician." This talk will attempt to shed new light on this mystery. (Received September 16, 2008)

1046-01-1693 **Daniel E. Otero*** (otero@xavier.xu.edu), Department of Mathematics & Computer Science, Xavier University, 3800 Victory Parkway, Cincinnati, OH 45207-4441. *Determining the determinant: the early years.*

The history of the development of the determinant – of a linear system of equations, of a square matrix, or of a linear endomorphism on a vector space – is a complex one. While this history has been studied carefully before, it is still not presently well known. This paper reviews the early years of this story, spanning the 18th century, and found in the work of many mathematicians: Leibniz, Maclaurin, Cramer, Bézout, Vandermonde, Laplace, Lagrange, Gauss, Binet, Cauchy, and Jacobi. It begins in the formulization of solutions to systems of equations and leads quickly to questions of what algebraic conditions impinge on the structure of solution sets. (Received September 16, 2008)

1046-01-1750 **Andrew B Perry*** (perryand@yahoo.com), 90 Longfellow Drive, Longmeadow, MA 01106. *Webster's "Arithmetick in Epitome" and other Eighteenth Century English Arithmetic Books.*

Evidence suggests that the Thomas Dilworth's "Schoolmaster's Assistant" was by far the most widely read arithmetic book in 18th century America. For example, 24 editions of this book were printed in the United States before 1800. This dreadful "Pandora's box of disconnected rules" (as Florian Cajori put it) probably gave both the subject of mathematics and the mathematicians of England an undeservedly bad reputation. William Webster's 1711 book "Arithmetick in Epitome" is a good example of an adequately logical and coherent exposition of arithmetic. The merits of this volume and other 18th century English arithmetics will be considered. (Received September 16, 2008)

1046-01-1918 **M ZUHAIR NASHED*** (znashed@mail.ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816. *Landmarks and Trails in the Development of Differential Calculus in Normed and Function Spaces.*

Differential Calculus in infinite dimensional spaces was developed along two schools. In the first school (Gateaux, Frechet, Levy, Hadamard)the "differential" was viewed as an element of an abstract space and the "derivative" as an operator, usually linear and continuous. In the second school (Volterra, von Mises) the approach was to generalize partial derivative (as a number) leading to the Volterra's concept of variational or functional derivative. We trace of the landmarks and trails in these developments, the emergence of the notion of "gradient" in function spaces, and failed and successful attempts to find the proper notions of derivaive in topological spaces. (Received September 16, 2008)

1046-01-2003 **Alexander G. Atwood*** (atwooda@sunysuffolk.edu), 533 College Road, Selden, NY 11784. *Connections between the Genesis of Mathematics and Writing in Ancient Mesopotamia in 3100 B.C. and the Neuroscience of Learning Mathematics Today.* Preliminary report.

In 7500 B.C. farmers in ancient Mesopotamia began to use three-dimensional stylized clay counting tokens to keep track of goods. By 3100 B.C. these tokens had evolved into two-dimensional written numerical symbols inscribed onto clay tablets in which the base-10 system and other systems were used. By 2600 B.C. written language had evolved from exclusively numerical concerns to encompass a full range of literary topics. Through the conception and representation of numbers in written form in Mesopotamia, both long-term memory and working (short-term) memory of the human brain were substantially enhanced and extended. Crucially, the ability to effectively harness working memory in the prefrontal cortex of the human brain is a vital component of fluid intelligence, which is the cognitive ability to solve new problems and draw connections between seemingly unrelated concepts. By enlarging working memory through the writing of mathematics, fluid intelligence can be substantially enhanced and transformed. How can the learning of mathematics by students today be transformed through their writing of mathematics and consequent enlargement of their working memory? What lessons can we learn from the genesis of mathematics in 3100 B.C. that can be applied to the learning of mathematics now? (Received September 16, 2008)

03 ► Mathematical logic and foundations

1046-03-105 **Barbara Csima***, University of Waterloo, Department of Pure Mathematics, Waterloo, Ontario N2L 3G1, Canada. *Computable Structure Theory.*

Abstract: In computable structure theory, one examines various countably infinite structures (such as linear orderings and graphs) for their computability theoretic properties. For example, the standard theorem that

any two countable dense linear orders without endpoints are isomorphic can be carried out computably, in the sense that if the two countable dense linear orders are nicely presented, then there must be a computable isomorphism between them. However, there are many examples of computable structures that are isomorphic but not computably isomorphic.

This talk will be an introduction to computable structure theory, explaining some standard examples, and indicating areas of current research. (Received September 09, 2008)

1046-03-107 **Rahim Moosa***, University of Waterloo, Department of Pure Mathematics, 200 University Avenue West, Waterloo, Ontario N2L 3G1, Canada. *Jet spaces and the Zilber dichotomy.*

In 2002, abstracting from a theorem in complex-analytic geometry, Anand Pillay introduced a certain model-theoretic condition, called the canonical base property (CBP), which is conjectured to hold in finite-rank theories. This condition is interesting because it provides a direct proof of the Zilber dichotomy in certain geometric contexts. What seems to be required in establishing the CBP in any given situation is an appropriate notion of "jet space". In my talk I will explain this circle of ideas and discuss recent developments. (Received September 09, 2008)

1046-03-108 **Christian Rosendal***, University of Illinois at Chicago, Dept. of Math., Stat., and Comp. Sci., 851 S. Morgan Street, m/c 249, Chicago, IL 60607-7045. *Descriptive set theory and the classification of separable Banach spaces.*

The classification problem for separable Banach spaces is notoriously difficult, so much that for a long time no one really seriously have believed that actual progres could be made on it. This belief is underscored by the tremendous developments in the geometric theory of Banach spaces in the '90s with the construction, especially by Gowers and Maurey, of a multitude of badly behaved spaces that showed that the variety of Banach spaces was even bigger than expected. On the other hand, Ramsey theoretical techniques introduced by Gowers indicate that, rather than hoping for an outright classification, one could attempt to classify spaces by finding recognisable subspaces present in all spaces (in logic terminology this is the "basis problem").

We shall present two separate pieces of work, one by Ferenczi, Louveau and Rosendal and the other by Ferenczi and Rosendal that prove the correctness of the first belief, respectively makes progress on the second type of classification. (Received September 10, 2008)

1046-03-109 **Albert Visser***, Utrecht University, Department of Philosophy, Heidelberglaan 8, 3584CS Utrecht, Netherlands. *Can we make the Second Incompleteness Theorem coordinate free?*

Is it possible to give a coordinate free formulation of the Second Incompleteness Theorem? Can we eliminate the arbitrariness of choices like the choice of the specific proof system, the representation of the axioms, the specific Gödel numbering employed? We pursue one possible approach to this question.

We show that (i) cutfree consistency for finitely axiomatized theories can be uniquely characterized modulo EA-provable equivalence, (ii) consistency for finitely axiomatized sequential theories can be uniquely characterized modulo EA-provable equivalence.

The case of infinitely axiomatized ce theories is more delicate. It seems to me that there are two ways to go. We can replace the single consistency statement by an infinity of restricted consistency statements. Alternatively, we can reaxiomatize the theory by a scheme. This can be done using a method disovered by Vaught. We will briefly discuss the scope of Vaught's result. The specific scheme produced by Vaught's result is crucially dependent of the representation of the axiom set. Thus, in this last approach, we can obtain independence of the choice of the proof system, but not of the representation of the axiom set. (Received September 10, 2008)

1046-03-110 **Jouko Väänänen***, University of Amsterdam, ILLC, Plantage Muidergracht 24, 1018 TV Amsterdam, Netherlands. *Set theoretic methods in model theory.*

I raise the question, how can we make sense of the statement that we have found an extremely complicated structure? The orbit of a countable structure is always on some level of the Borel hierarchy. The transfinite levels of the Borel hierarchy, calibrated by countable ordinals, put countable structures on levels. The higher the level, the more complicated the structure. What about uncountable structures? Models of cardinality $\aleph_1$ can be thought of as points in the space $\mathcal{N}_1$ of functions $f : \omega_1 \to \omega_1$, endowed with the G_δ topology. The class of *Borel* sets of the space $\mathcal{N}_1$ is the smallest class of sets containing the open sets and closed under complements and unions of length ω_1. A set is *analytic* if it is a continuous image of a closed subset of $\mathcal{N}_1$. Orbits of structures of cardinality $\aleph_1$ are, a priori, *analytic*, but are they Borel? We give an overview of set-theoretic and model-theoretic methods for getting at least partial solutions to this problem. (Received September 10, 2008)

1046-03-118 **Achim Blumensath*** (blumensath@mathematik.tu-darmstadt.de) and **Bruno Courcelle** (Bruno.Courcelle@labri.fr). *On the Monadic Second-Order Transduction Hierarchy.*

We compare classes of finite relational structures via monadic second-order transductions. More precisely, we study the preorder

$$\mathcal{C} \sqsubseteq \mathcal{K} \quad \text{iff} \quad \mathcal{C} \subseteq \tau(\mathcal{K}) \quad \text{for some transduction } \tau\,.$$

If we only consider classes of *incidence structures* we can completely describe the resulting hierarchy. It is linear of order type $\omega + 3$. Each level can be characterised in terms of a suitable variant of tree-width. Canonical representatives of the various levels are: the class of (i) all trees of height n, for $n \in \mathbb{N}$; (ii) all paths; (iii) all trees; and (iv) all grids. (Received September 11, 2008)

1046-03-292 **Stephen G. Simpson*** (simpson@math.psu.edu), Department of Mathematics, McAllister Building, Pollock Road, Pennsylvania State University, State College, PA 16802. *Symbolic dynamics and degrees of unsolvability.*

Let A be a finite set of symbols. The 2*-dimensional shift space on* A is $A^{\mathbb{Z}\times\mathbb{Z}}$ with shift operators S_1 and S_2 given by $S_1(x)(m,n) = x(m+1,n)$ and $S_2(x)(m,n) = x(m,n+1)$. A 2*-dimensional subshift* is a nonempty, closed subset of $A^{\mathbb{Z}\times\mathbb{Z}}$ which is invariant under S_1 and S_2. A 2-dimensional subshift is said to be *of finite type* if it is defined by a finite set of excluded finite configurations of symbols. We regard real numbers and points of $A^{\mathbb{Z}\times\mathbb{Z}}$ as Turing oracles. If X and Y are sets of Turing oracles, we say that X *is Muchnik reducible to* Y if each $y \in Y$ computes some $x \in X$. The *Muchnik degree of* X is the equivalence class of X under mutual Muchnik reducibility. We prove that the Muchnik degrees of 2-dimensional subshifts of finite type are the same as the Muchnik degrees of nonempty, effectively closed sets of real numbers. We then apply known results about such Muchnik degrees to obtain an infinite family of 2-dimensional subshifts of finite type which are, in a certain strong sense, mutually independent. Our application is stated purely in terms of symbolic dynamics, with no mention of Muchnik reducibility. (Received August 26, 2008)

1046-03-337 **Lavinia Corina Ciungu*** (lcciungu@buffalo.edu), 107 Springville Avenue Ap.1, Buffalo, NY 14226. *Convergence with a fixed regulator in residuated lattices.*

The notion of convergence in multiple-valued logic algebras proved to be very important for the study of continuous states on these structures. Various concepts of convergence have been defined on lattice-ordered algebras. For a lattice ordered-group, the order convergence is studied by Papangelou and alpha-convergence is presented by Ball. The sequential convergence on generalized Boolean algebras is defined and studied by Jakubik. The order-convergence in case of MV-algebras is presented by Ball and various kinds of Cauchy completions of MV-algebras are studied by Georgescu, Liguori, Martini. Cernak introduced the convergence with a fixed regulator for MV-algebras. We investigated the convergence with a fixed regulator for the particular case of perfect MV-algebras. The notion of similarity convergence in a residuated lattice was introduced by Georgescu, Popescu. In this paper we introduce the notion of convergence with a fixed regulator in residuated lattices and study some properties of this convergence. We prove that every sequence of an Archimedean residuated lattice has a unique v-limit. We also prove that a complete residuated lattice is also v-Cauchy complete. The corresponding topology of the v-convergence is constructed. (Received August 26, 2008)

1046-03-338 **Johann A. Makowsky*** (janos@cs.technion.ac.il). *Towards a theory of graph polynomials.* Preliminary report.

We survey our attempts to create a unifying theory of graph polynomials such as the chromatic polynomial, the Tutte polynomial and its generalizations, the interlace polynomial, and many others. We combine methods from model theory, such as definability criteria in fragments of second order logic and Feferman-Vaught type theorems, methods from algebra, such as generalized connection matrices, and methods from complexity theory. (Received August 27, 2008)

1046-03-366 **Gregory L. Cherlin***, 110 Frelinghuysen Rd., Piscataway, NJ 08854. *Universal graphs with forbidden subgraphs.* Preliminary report.

The problem under consideration is the existence of a countable universal graph within the collection of countable graphs omitting a finite set of forbidden subgraphs. Ultimately the question is whether this is an algorithmically decidable problem as one varies the set of constraints. The model theoretic approach we developed with Shelah and Shi translates each instance of this problem into the problem of estimating the size of the algebraic closure of a finite set, where the notion of algebraic closure used depends directly on the set of forbidden subgraphs. As an application one may determine the cases in which there is a universal graph for the class of graphs omitting a specified tree. Ongoing work with Shelah suggests that it might be possible to treat the case of any single constraint along similar lines. In principle a similar analysis can be applied to other combinatorial structures, such as permutations omitting a pattern. (Received August 28, 2008)

1046-03-393 **Tomer Kotek*** (tkotek@cs.technion.ac.il), **Johann A. Makowsky** (janos@cs.technion.ac.il) and **Boris Zilber** (zilber@maths.ox.ac.uk). *Why is the chromatic polynomial a polynomial? A model theoretic interpretation.*

The notion of graph polynomials definable in Monadic Second Order Logic, MSOL, was introduced by B. Courcelle, J.A. Makowsky and U. Rotics in 2001. It was shown later that the Tutte polynomial and its generalization, as well as the matching polynomial, the cover polynomial and the various interlace polynomials fall into this category.

In this talk we present a model theoretic framework of graph polynomials based on counting functions of generalized colorings. We show that this class encompasses the examples of graph polynomials from the literature. Furthermore, we extend the definition of graph polynomials definable in MSOL to allow definability in full second order, SOL. Finally, we show that the SOL-definable graph polynomials extended with a combinatorial counting function are exactly the counting functions of generalized colorings definable in SOL. (Received August 30, 2008)

1046-03-471 **Andreas Blass*** (ablass@umich.edu), Mathematics Department, University of Michigan, Ann Arbor, MI 48109-1043. *Partition theorems and permutation groups.* Preliminary report.

Several partition theorems, including Ramsey's and van der Waerden's, can be formulated in terms of permutation actions of certain groups. These formulations originally came up in the study of permutation models for set theory without the axiom of choice. More recently, they have acquired connections in other directions. (Received September 04, 2008)

1046-03-498 **Bruno Durand**, **Andrei Romashchenko** and **Alexander Shen*** (alexander.shen@lif.univ-mrs.fr,sasha.shen@gmail.com). *Fixed-point aperiodic tilings.*

A new construction of an aperiodic tile set (Berger's theorem) is suggested based on the construction similar to the fixed-point (Kleene recursion) theorem. This construction is rather flexible so it can be used to ensure some additional properties of the tile set: error robustness, variable zoom factor, implementation of substitution rules. In this way we get a new construction of a tile set that has tiling of maximal Kolmogorov complexity and this set can be made robust. (Received September 05, 2008)

1046-03-661 **Inessa Epstein***, Mathematics 253-37, Caltech, Pasadena, CA 91125. *Orbit equivalence and ergodic actions of countable groups.*

Consider a countable group G acting in a Borel way by measure preserving automorphisms on a standard probability space X. The orbits of this action give rise to an equivalence relation on X. We say two measure preserving actions of groups G and H on spaces X and Y, respectively, are orbit equivalent if there is a measure preserving bijection between conull subsets of X and Y identifying the orbits.

The motivation for studying orbit equivalence originally stemmed from operator algebras. In this talk, I will discuss a result concerning the number of orbit inequivalent free, measure preserving, ergodic actions that exist for a given countable group. I will also consider the Borel complexity of the classification problem of the orbit equivalence of these actions. (Received September 09, 2008)

1046-03-710 **Douglas Cenzer*** (cenzer@ufl.edu), Department of Mathematics, P.O. Box 118105, University of Florida, Gainesville, FL 32611-8105, and **S. Ali Dashti**. *Decidability of countable closed subshifts.* Preliminary report.

A closed subset of 2^N is a *subshift* if it is closed under the shift operator σ, where $\sigma(X(0), X(1), ...) = (X(1), X(2), ...)$. The authors recently showed (Math. Logic Quarterly, 2008) that there exists an effectively closed (Π^0_1) subshift with no computable member. We now investigate countable Π^0_1 subshifts. It is shown, for example, that any Π^0_1 subshift of rank one is decidable, whereas there is an undecidable Π^0_1 subshift of rank two. (Received September 10, 2008)

1046-03-716 **Christian Rosendal*** (rosendal@math.uic.edu), University of Illinois at Chicago, 322 Science and Engineering Offices (M/C 249), 851 S. Morgan Street, Chicago, IL 60607. *Generic isometries and measure preserving homeomorphisms are conjugate to their powers.*

We consider the groups of isometries of the rational Urysohn metric space and (Haar) measure preserving homeomorphisms of Cantor space. It is well known that these groups admit comeagre conjugacy classes and we show that any element of this conjugacy class is also conjugate to all of its integers powers. This can be used to construct roots of all orders of the generic element of these groups. (Received September 10, 2008)

1046-03-724 **Asger Tornquist*** (asger@math.utoronto.ca), 40 St. George Street, room 6290, University of Toronto, Toronto, Ontario M5S2E4, Canada. *The classification problem for separable von Neumann factors.*

In von Neumann algebra theory, a factor is a von Neumann algebra in which the center consists of multiples of the identity. Factors make up the building blocks out of which any other von Neumann algebra can be build. The problem of classifying von Neumann factors is therefore as old as the subject itself.

In this talk I will discuss a recent result (joint with Roman Sasyk, Ottawa), where we show that separable von Neumann factors are not classifiable by a reasonable assignment of invariants that are countable structures, in particular, there is no suitably "Borel" assignment of countable groups, graphs or other countable structures as complete invariants for the isomorphism relation of separable factors. The proof involves among other things Greg Hjorth's theory of turbulence, the group-measure space construction, and the deformation/rigidity techniques developed by Sorin Popa. (Received September 10, 2008)

1046-03-786 **S. Ali Dashti*** (samdashti@gmail.com), Department of Mathematics, P.O. Box 118105, University of Florida, Gainesville, FL 32611-8105, and **Douglas Cenzer**. *Computable dynamics of real functions.* Preliminary report.

The iteration of a continuous function F on 2^N defines for each $X \in 2^N$ an *itinerary* $It(X)$: the sequence $< F^n(X)(0) >$. Then IT_F is the (closed) set of all itineraries; this is the *symbolic dynamics* of F. The set IT_F is always a *subshift*, that is IT_F is closed under the shift operator σ, where $\sigma(X(0), X(1), ...) = (X(1), X(2), ...)$. The authors recently showed (Math. Logic Quarterly, 2008) that for a computable F, IT_F is a decidable Π^0_1 class, that is, the set of intervals which meet IT_F is a computable set. Furthermore, any decidable subshift is the set of itineraries of some computable function. The present paper continues the investigation of the symbolic dynamics of computable real functions. (Received September 11, 2008)

1046-03-824 **Yun Lu*** (lu@kutztown.edu), Mathematics Department, Kutztown University of Pennsylvania, Kutztown, PA 19530. *Reducts of generalized random bipartite graph.*

In this talk, I will review the classification of reducts given by Thomas and Bennett, then follow with my own work classifying the irreducible reducts of the random bipartite graph with three or more cross types. (Received September 11, 2008)

1046-03-976 **Scott Schneider*** (scottsch@math.rutgers.edu), Department of Mathematics, Rutgers University, 110 Frelinghuysen Road, Piscataway, NJ 08854-8019. *Bernoulli Actions of Property (τ) Groups.* Preliminary report.

We will discuss the use of entropy in the study of factors of Bernoulli systems and present some applications to the theory of countable Borel equivalence relations. In particular, we will show that if $p \neq q$, then the orbit equivalence relations arising from Bernoulli actions of $SL_2(\mathbb{Z}[\sqrt{p}])$ and $SL_2(\mathbb{Z}[\sqrt{q}])$ are incomparable with respect to Borel reducibility. (Received September 13, 2008)

1046-03-1054 **Jennifer Chubb*** (jennifer.chubb@gmail.com), Dept. of Mathematics, Monroe Hall, Room 240, 2115 G St. NW, Washington, DC 20052. *Countable groups and their orderings.*

The collection of orderings of a countable group may be represented as the paths of a subtree of the full binary tree. The properties such trees may have vary with the group and the type of orderings considered. I will survey some results on topological and algorithmic properties of the collection of orderings of countable groups. Buttsworth gave an example witnessing that the collection of bi-orderings of a countable group may be exactly countably infinite, so the corresponding tree has countably many paths. This is impossible for any collection of left-orderings of a group. A group is computable if there are algorithms for determining the group elements and for computing the group operation, and an ordering is computable if there is an algorithm that will determine when a group element is positive. Downey and Kurtz gave an example of a computable abelian group admitting no computable ordering of its elements, so the corresponding tree has no computable paths. (Received September 14, 2008)

1046-03-1104 **Vladimir G. Pestov*** (pestovv@member.ams.org), Department of Mathematics and Statistics, University of Ottawa, 585 King Edward Avenue, Ottawa, Ontario K1N 6N5, Canada. *Matrix models for discrete and topological groups.*

A discrete group Γ admits a matrix model (or is hyperlinear) if Γ embeds into an ultraproduct of unitary groups $U(n)$, $n \in \mathbb{N}$ equipped with the normalized Hilbert-Schmidt distance, with regard to some (any) non-principal ultrafilter on natural numbers, formed in the same way as ultraproducts of Banach spaces. (The expression "matrix model" comes from Mathematical Physics by way of Operator Algebras, but the above property of Γ can indeed be stated in terms of model theory of continuous structures in the sense of Ben Yaacov, Berenstein, Henson, and Usvyatsov.) It remains unknown whether every group admits a matrix model. The importance of this question comes from its close link to a number of open problems in various areas of mathematics, above all Connes' Embedding Conjecture for Operator Algebras, but also solvability of equations in groups, and others. We will survey some known and new results and open problems, and also discuss a natural extension of matrix models to metric groups, which allows for the first time to bring into the picture a number of well-known infinite-dimensional groups, such as the group of measure preserving transformation of a standard Lebesgue measure space, full groups of measure-preserving equivalence relations, etc. (Received September 14, 2008)

1046-03-1123 **Jeremy Avigad*** (avigad@cmu.edu), Department of Philosophy, Baker Hall 135, Carnegie Mellon University, Pittsburgh, PA 15213. *Computability in Ergodic Theory.*

Let T be a measure-preserving transformation of a space $(X, \mathcal{B}, \mu)$, let f be a measurable function from X to $\mathbb{R}$, and for every $x \in X$ and $n \in \mathbb{N}$ let $(A_n f)x = (fx + f(Tx) + \ldots + f(T^{n-1}x))/n$. The pointwise ergodic theorem says that this sequence of averages converges for almost every x, and the mean ergodic theorem says that the sequence $(A_n f)$ converges in the L^2 norm.

In general, one cannot compute a rate of convergence from the initial data. Describing joint work with Philipp Gerhardy and Henry Townser, I will explain how proof-theoretic methods provide classically equivalent formulations of the ergodic theorems which are computably valid, and yield additional information. Specifically, the mean ergodic theorem is equivalent to the assertion that for every function $K(n)$ and every $\varepsilon > 0$, there is an n with the property that the ergodic averages $A_m f$ are stable to within ε on the interval $[n, K(n)]$. Even in situations where the sequence $(A_n f)$ does not have a computable limit, one can give explicit bounds on such n in terms of K and $\|f\|/\varepsilon$. These bounds can be used to obtain a similarly explicit version of the pointwise ergodic theorem as well. (Received September 14, 2008)

1046-03-1128 **Joseph S Miller*** (jmiller@math.wisc.edu), University of Wisconsin—Madison, Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706–1388. *Two notes on subshifts.*

First, we show that every Π^0_1 Medvedev degree contains a Π^0_1 subshift. This answers a question of Steve Simpson, who proved that every Π^0_1 Medvedev degree contains a 2-dimensional subshift of finite type, i.e., one for which the set of forbidden 2-dimensional words is finite. It also relates to recent work of Cenzer, Dashti and King, who studied Π^0_1 subshifts. Second, we give a condition on a set of forbidden words that is sufficient to guarantee that the corresponding subshift is nonempty. (Received September 14, 2008)

1046-03-1162 **C T Chong***, Department of Mathematics, National University of Singapore, Kent Ridge, 117543, Singapore. *Complex dynamics and Turing degrees.* Preliminary report.

Arising from the work of Braverman and Yampolsky, we study some recursion-theoretic aspects of complex dynamical systems, especially in the case of quadratic polynomials. (Received September 14, 2008)

1046-03-1219 **Philipp Gerhardy*** (Philipp.Gerhardy@gmail.com), Department of Mathematics, The University of Oslo, Blindern, N-0316 Oslo, Norway. *Proof mining in topological dynamics.*

With the Multiple Birkhoff Recurrence theorem by Furstenberg and Weiss in 1978 is a seminal result for the interaction between topological dynamics and combinatorics, establishing Ramsey-type theorems through corresponding recurrence results. However, while combinatorial proofs often contain explicit quantitative information, topological proofs usually do not contain realizers, bounds or similar data. E.g. for van der Waerden's theorem – for every finite colouring of the integers one colour contains arbitrarily long arithmetic progressions – one may ask for a number $N = N(q, k)$ such that for every q-colouring of $[0, N]$ one colour contains a progression of length k. The combinatorial proof contains an explicit upper bound on $N(q, k)$, while Furstenberg and Weiss' topological proof does not. Thus one may ask: what is the algorithmic content of the topological proofs of Ramsey-type theorems. We will present an analysis of Furstenberg and Weiss' Multiple Birkhoff Recurrence theorem which generalizes a previous analysis by Girard. We will discuss the use of compactness in proofs of the Multiple Birkhoff Recurrence theorem, i.e. the concept of minimality in topological dynamics, and sketch the treatment of generalizations of the Multiple Birkhoff Recurrence theorem. (Received September 15, 2008)

1046-03-1298 **David Reed Solomon*** (solomon@math.uconn.edu), Department of Mathematics, 196 Auditorium Road, University of Connecticut, U-3009, Storrs, CT 06269-3009.
Computability theoretic aspects of ordered groups.

In this talk we will examine some of the common questions arising in computable model theory and effective algebra in the context of ordered abelian groups. (Received September 15, 2008)

1046-03-1337 **Oscar Levin*** (olevin@math.uconn.edu), 196 Auditorium Road, Unit 3009, Storrs, CT 06269. *Computable Dimension of Ordered Fields.*

In computable model theory, two computable structures can be isomorphic, yet lack any computable isomorphism between themselves. The computable dimension of a structure $\mathcal{A}$ counts the number of isomorphic, but not computably isomorphic, computable copies of $\mathcal{A}$. For instance, if the structure is an algebraically closed field, then the computable dimension is always either 1 or ω, depending on the transcendence degree of the field. In this talk we will explore the possibilities of computable dimension (and related notions) when the structures are ordered fields. (Received September 15, 2008)

1046-03-1348 **Steve C Jackson*** (jackson@unt.edu), Department of Mathematice, University of North Texas, Denton, TX 76203-5017, **Su Gao** (sgao@unt.edu), Department of Mathematics, University of North Texas, Denton, TX 76203-5017, and **Brandon Seward**, Department f Mathematics, University of North Texas, Denton, TX 76203-5017. *A compactness theorem for markers and group colorings.* Preliminary report.

We formulate a compactness property for complete sections of Borel equivalence relations. This is a natural notion arising from hyperfiniteness proofs and related questions. The compactness property, in turn, leads to a purely algebraic question about groups. We formulate this as a coloring property of countable groups and investigate it. (Received September 15, 2008)

1046-03-1523 **John D. Clemens*** (clemens@math.psu.edu), Mathematics Department, Penn State University, University Park, PA 16802. *The isomorphism problem for subshifts.*

We use the theory of Borel equivalence relations to analyze the equivalence relation of topological isomorphism among one-dimensional subshifts. We show that this equivalence relation is a universal countable Borel equivalence relation, i.e., it admits no definable complete invariants fundamentally simpler than the equivalence classes. We also see that the classification of higher dimensional subshifts up to isomorphism has the same complexity as for the one-dimensional case. (Received September 15, 2008)

1046-03-1667 **Wesley Calvert**, Dept. of Mathematics & Statistics, Faculty Hall 6C, Murray State University, Murray, KY 42071, and **Russell Miller*** (Russell.Miller@qc.cuny.edu), Mathematics Dept., Queens College – CUNY, 65-30 Kissena Blvd., Flushing, NY 11367.
Real Computability and Manifolds. Preliminary report.

We use two versions of the Blum-Shub-Smale notion of computability on real numbers to produce reasonable definitions of real-computable manifolds. We then consider questions about the decidability of nullhomotopy and simple connectedness for such manifolds. (Received September 16, 2008)

1046-03-1669 **Inessa Epstein***, Mathematics 253-37, Caltech, Pasadena, CA 91125, and **Greg Hjorth**.
Equivalence relations with infinitely many ends and percolation.

We analyze countable Borel equivalence relations with many ends and the actions of groups with many ends. As a consequence of this work we obtain a result regarding the percolation on non-amenable groups that have infinite normal amenable subgroups. (Received September 16, 2008)

1046-03-1677 **Matthew A Jura*** (jura@math.uconn.edu), 15 Baxter Rd, Mansfield, CT 06268. *Reverse Mathematics of Theorems Involving the Coloring Number of Graphs.*

We use reverse mathematics to analyze the proof theoretic strength of theorems that involve the notion of the coloring number of graphs. The coloring number $\mathrm{Col}(G)$ of a countable graph G is the least $k \leq \omega$ such that there is a well ordering of G for which each node $g \in G$ has at most k many predecessors connected to g by an edge. (Received September 16, 2008)

1046-03-1799 **Tyler J Markkanen*** (markkanen@math.uconn.edu), 647 Cherry Brook Rd, Canton, CT 06019. *Separating the Degree Spectra of Structures.*

In computable model theory, the notion of degree spectrum is very interesting when studying the computable properties of a countable structure $\mathfrak{A}$. The degree spectrum of $\mathfrak{A}$, denoted $\mathrm{DgSp}(\mathfrak{A})$, is the set $\{\deg(\mathfrak{B}) \mid \mathfrak{B} \cong \mathfrak{A}\}$, where $\deg(\mathfrak{B})$ is the Turing degree of $\mathfrak{B}$.

Now, pick your two favorite classes of structures: $\mathcal{C}_1$ and $\mathcal{C}_2$ (e.g., choose two from a list like: linear orderings, graphs, and boolean algebras). In this talk, we will investigate one kind of question in particular: "Given a structure $\mathfrak{A} \in \mathcal{C}_1$, is it the case that $\mathrm{DgSp}(\mathfrak{A}) \neq \mathrm{DgSp}(\mathfrak{B})$ for *any* structure $\mathfrak{B} \in \mathcal{C}_2$?" An answer of "Yes" will separate $\mathcal{C}_1$ from $\mathcal{C}_2$ in a computability theoretic way.

Specifically, we will answer "Yes" to this question when $\mathcal{C}_1 =$ linear orderings and $\mathcal{C}_2 =$ finite-component graphs. We will also see how the technique used to give this answer may lead to more general classes of structures for $\mathcal{C}_1$ and $\mathcal{C}_2$. (Received September 16, 2008)

05 ► Combinatorics

1046-05-81 **Joshua K. Lambert*** (joshua.lambert@ndsu.edu), Department of Mathematics, 302F Minard Hall, North Dakota State University, Fargo, ND 58105-5075. *The Biplanar Crossing Number of $C_k \times C_l \times C_{2m} \times P_n$.* Preliminary report.

In the article *Biplanar crossing numbers I: A survey of results and problems*, Czabarka, Sýkora, Székely, and Vrto asked for the biplanar crossing number of $C_n \times C_n \times C_n \times P_n$. The aim of this work is to expand upon this open question. In this paper we will find a biplanar imbedding of $C_k \times C_l \times C_{2m} \times P_n$. We will use an embedding of gridlike graph on the first plane, and then find the appropriate planar decomposition of the given graph to form our desired imbedding on the second plane. (Received September 09, 2008)

1046-05-84 **Gerald S Haynes***, Department of Mathematics, Central Michigan University, Mount Pleasant, MI 48859. *Vector Coloring.*

In the usual sense, vertex-coloring a graph consists of coloring each vertex so that if two vertices $u, v \in V$ are connected by an edge, then the color of v is different from the color of u. The minimum number of colors necessary for such a coloring is called the chromatic number of G, $\chi(G)$. We could also assign to each vertex a list of colors, and require that the color of the vertex be chosen from this list. We define G to be k-list colorable if for every assignment of lists of size k, we can find a valid coloring.

For this project, we introduce a non-discrete analogue called vector coloring. We define a valid vector coloring to be a coloring that assigns to each vertex a vector, where two vertices connected by an edge are assigned orthogonal vectors. If we assign to each vertex a subspace of some inner product space, and choose the vectors to be from these subspaces, we call this a subspace coloring. We define G to be k-subspace colorable if for any subspace assignments of dimension k, we can find a valid vector coloring for G. In 1979, Erdos completely characterized all graphs with list chromatic number 2. We explore these graphs to characterize all 2-subspace colorable graphs. (Received July 22, 2008)

1046-05-155 **Victor O. Larsen*** (vlarsen@middlebury.edu), 3501 Middlebury College, Middlebury, VT 05753. *A Tree with Maximum Degree Three and Game Chromatic Number Four.* Preliminary report.

We examine the following coloring game played on a graph G. Given a fixed positive integer r, Alice and Bob alternately color the vertices of G with r colors. Alice makes the first move. The game ends when no more vertices can be legally colored. A color α is legal for a vertex u if no neighbors of u are colored with α. If the entire graph is eventually colored, Alice wins. If there exists any uncolored vertex with no legal color, then Bob wins. The least r such that Alice has a winning strategy is called the game chromatic number of G. This parameter has been examined in many other papers, and it has been proven that every tree has game chromatic number at most 4. We show that there exists a tree with maximum degree 3 on which Alice does not have a winning strategy using only 3 colors. This proves that there exists a tree with maximum degree 3 and game chromatic number 4. (Received August 07, 2008)

1046-05-159 **Lynnette Snyder*** (lynnette.snyder@simpson.edu). *The Relaxed Coloring Game on Certain Classes of Trees.* Preliminary report.

We consider the (r, d)-relaxed coloring game on different classes of graphs. Two players, Alice and Bob, color the vertices of a graph G with r colors. Alice has the first move. A color α is legal for a vertex x if x has at most d neighbors colored α, and if w, a neighbor of x colored α, has at most $d-1$ neighbors colored α. Alice wins if every vertex is colored, while Bob wins if at some point an uncolored vertex has no legal color. We show that Alice has a winning strategy in the $(2, 1)$-coloring game on stars and extensions of stars. (Received August 07, 2008)

1046-05-223 **Hsin-Hao Lai** and **Ko-Wei Lih*** (makwlih@sinica.edu.tw), Institute of Mathematics, Academia Sinica, Nankang, Taipei, 11529, Taiwan, and **Li-Da Tong**. *Fully Orientability of Graphs with at Most One Dependent Arc.*

Suppose that D is an acyclic orientation of a graph G. An arc of D is *dependent* if its reversal creates a directed cycle. Let $d_{\min}(G)$ ($d_{\max}(G)$) denote the minimum (maximum) of the number of dependent arcs over all acyclic orientations of G. We call G *fully orientable* if G has an acyclic orientation with exactly d dependent arcs for every d satisfying $d_{\min}(G) \leqslant d \leqslant d_{\max}(G)$. We show that a connected graph G is fully orientable if $d_{\min}(G) \leqslant 1$. This generalizes the main result in Fisher et al., *J. Combin. Theory Ser. B 71 (1997), 73-78.* (Received August 20, 2008)

1046-05-240 **Lara K. Pudwell*** (Lara.Pudwell@valpo.edu), Department of Mathematics & Computer Science, 1900 Chapel Drive, Valparaiso, IN 46383. *An Introduction to Enumeration Schemes.*

Given permutations p and q, we say that p contains q as a pattern if p has a subsequence that is order-isomorphic to q. Otherwise, we say that p avoids q. The study of these pattern-avoiding permutations yields a number of challenging enumeration questions. I will introduce the method of enumeration schemes, which is an algorithmic way to find recurrences for counting sets of permutations that avoid forbidden patterns. (Received August 21, 2008)

1046-05-276 **Robert P Boyer*** (rboyer@math.drexel.edu), Philadelphia, PA 19104, and **William M. Y. Goh**, Hefei, 230026, Peoples Rep of China. *Asymptotics and Zeros for Polynomials from Combinatorics.*

Natural families of polynomials appear in many branches of mathematics such as number theory, combinatorics, knot theory, and analysis. In general, their zeros are complex; furthermore, their zeros may have limiting shapes in the plane as the degrees go to infinity.

In this talk, we focus on the experimentation for Appell polynomials and different polynomial families associated with integer partitions that has been successful. We will also indicate some pitfalls in computation. (Received August 25, 2008)

1046-05-277 **Blair D Sullivan*** (sullivanb@ornl.gov), Oak Ridge National Laboratory, P.O. Box 2008, MS 6015, Oak Ridge, TN 37831. *Counting Paths in Digraphs.*

Say a digraph is k-free if it has no directed cycles of length at most k, for $k \in \mathbb{Z}^+$. Thomassé conjectured that the number of induced 3-vertex directed paths in a simple 2-free digraph on n vertices is at most $(n-1)n(n+1)/15$. We survey Bondy's proof that there are at most $2n^3/25$ such paths, and present the new result that, for the class of circular interval digraphs, a tight upper bound of $n^3/16$ holds. We also show an application of Bondy's result to the problem of bounding the number of (non-induced) 4-vertex paths in 3-free digraphs (we prove there are at most $4n^4/75$). (Received August 25, 2008)

1046-05-333 **Jennifer R. Vandenbussche*** (jvandenb@spsu.edu), SPSU, Mathematics Department, 1100 South Marietta Pkwy, Marietta, GA 30060, and **Douglas B. West**. *Matching extendability in the hypercube.* Preliminary report.

We explore conditions under which matchings in the d-dimensional hypercube extend to perfect matchings. In a bipartite graph G, a set $S \subseteq V(G)$ is *deficient* if the vertices of S together have fewer than $|S|$ neighbors. Let M be a matching (with vertex set U) in the d-dimensional hypercube such that $Q_d - U$ has no deficient set of size less than k. If $|M| \leq k(d-k) + \binom{k-1}{2}$, then M extends to a perfect matching. Furthermore, this result is sharp. (Received September 15, 2008)

1046-05-339 **Gabor Elek** and **Balasz Szegedy*** (szegedy@math.toronto.edu). *Non standard methods in hypergraph theory.* Preliminary report.

We demontrate a new measure theoretic method based on the ultra product of finite measure spaces which gives short proofs for results in hypergraph theory such as the regularity lemma and the testability of hereditary hypergraph properties. We prove several new results about hypergraphs, sampling, hypergraph sequences, various convergence notions and limit objects. (Received August 27, 2008)

1046-05-340 **Stephan Kreutzer*** (stephan.kreutzer@comlab.ox.ac.uk), Oxford University Computing Laboratory, University of Oxford, Wolfson Building, Parks Road, Oxford, OX1 3QD, England. *Algorithmic Meta-Theorems.*

Algorithmic meta-theorems are general algorithmic results applying to a whole range of problems, rather than just to a single problem alone. They often have a *logical* and a *structural* component, that is they are results of the form: *"every computational problem that can be formalised in a given logic $\mathcal{L}$ can be solved efficiently on every class $\mathcal{C}$ of structures satisfying certain conditions."*

Beginning with Courcelle's result that every property of graphs definable in monadic second-order logic can be decided in linear time on any class of structures of bounded tree-width, algorithmic meta-theorems have been established for a range of logics and graph classes. In particular, graph classes defined by concepts originating in graph minor theory have received significant attention.

With their logical and combinatorial, graph theoretical component, algorithmic meta-theorems establish a link between combinatorics or algorithms theory and computational logic.

In this talk I will survey recent results in this area and present challenges for current and future research, especially in establishing intractability results for natural graph classes and logics. (Received August 27, 2008)

1046-05-341 **Jan Hubicka** (hubicka@kam.mff.cuni.cz) and **Jaroslav Nesetril*** (nesetril@kam.mff.cuni.cz), Department of applied mathematics (KAM) and, Institute of theoretical CS (ITI), Charles University, 11800 Prague, Czech Rep. *Homomorphism universal structures.*

We present a combinatorial construction of (embedding) universal objects for classes defined by forbidden homomorphisms by means of lifts. This leads to a new construction of duals of trees. (Received August 27, 2008)

1046-05-342 **Menachem Kojman*** (kojman@cs.bgu.ac.il). *Symmetrized Ramsey theorems for graphs and for countably categorical structures.* Preliminary report.

A symmetrized Ramsey theorem is one which requires that the monochromatic substructure satisfies that each of its automorphisms extends to an automorphism of the colored structure. Using results of Hrushovski, Babai and Sos, and otheres, we prove that certain induced Ramsey theorems can be strengthened to symmetrized induced theorems. (Received August 27, 2008)

1046-05-343 **Eldar Fischer*** (eldar@cs.technion.ac.il) and **Johann A. Makowsky** (janos@cs.technion.ac.il). *The Specker-Blatter theorem revisited.* Preliminary report.

While many results in combinatorics provide asymptotic estimates for the number of structures satisfying a given property, the Specker-Blatter Theorem (1981) is one of the few results dealing with the "low-order digits". This result exhibits a modular recurrence relation for counting the number of ways a set with n elements can be equipped with unary and binary relations satisfying a property definable in monadic second order logic.

We survey some recent developments. In particular we outline an example showing that the theorem does not hold over quaternary relations, and proofs for some additional cases in which it does hold. (Received August 28, 2008)

1046-05-354 **Elizabeth Reilly**, Dept. of Applied Mathematics and Statistics, Johns Hopkins University, Baltimore, MD 21218, and **Edward R. Scheinerman*** (ers@jhu.edu), Dept. of Applied Mathematics and Statistics, Johns Hopkins University, Baltimore, MD 21218. *Random threshold graphs.*

A *random threshold graph* is a simple graph with vertex set $\{1, 2, \ldots, n\}$ that is generated as follows: Let $x_1, x_2, \ldots, x_n$ be n values chosen uniformly and independently from $[0, 1]$. Join distinct vertices u and v by an edge if and only if $x_u + x_v > 1$. We discuss various properties of random threshold graphs. For example, the probability that a random threshold graph on n vertices has a Hamiltonian cycle is asymptotically $1/\sqrt{2\pi n}$. (Received August 27, 2008)

1046-05-371 **Geir Agnarsson** and **Jill Bigley Dunham*** (jbigley@gmu.edu). *Extremal Coin Graphs in the Euclidean Plane.* Preliminary report.

A coin graph is a simple geometric intersection graph where the vertices are represented by non-overlapping closed disks in the Euclidean plane and where two vertices are connected if their corresponding disks touch. The problem of determining the maximum number of edges of a unit coin graph on n vertices, where all the radii are of unit length, is well known and has a beautiful solution.

In this talk we consider related extremal problems of coin graphs that satisfy certain natural conditions relating to the ratios of the possible radii of the coins of the graph. Further, we will explore the algebraic equations describing wheel graphs, as they relate to the maximum number of edges in our mentioned coin graphs. (Received August 28, 2008)

1046-05-373 **Robert Gilman**, **Yuri Gurevich** and **Alexei Myasnikov*** (alexeim@math.mcgill.ca), Department of Mathematics and Statistics, McGill University, 805 Sherbrooke Street W., Montreal, Quebec H3A 2K6, Canada. *A Geometric Zero-One Law.*

Each relational structure X has an associated Gaifman graph, which endows X with the properties of a graph. If x is an element of X, let $B_n(x)$ be the ball of radius n around x. Suppose that X is infinite, connected and of bounded degree. A first-order sentence ϕ in the language of X is almost surely true (resp. a.s. false) for finite substructures of X if for every $x \in X$, the fraction of substructures of $B_n(x)$ satisfying ϕ approaches 1 (resp. 0) as n approaches infinity. Suppose further that, for every finite substructure, X has adisjoint isomorphic substructure. Then every ϕ is a.s. true or a.s. false for finite substructures of X. This is one form of the geometric zero-one law. We formulate it also in a form that does not mention the ambient infinite structure. In addition, we investigate various questions related to the geometric zero-one law. (Received August 28, 2008)

1046-05-376 **Katherine P. Benedetto** and **Nicholas A. Loehr*** (nloehr@vt.edu), 460 McBryde Hall, Dept. of Mathematics, Blacksburg, VA 24060. *Tiling Bijections via Finite Automata.*

This talk explores some combinatorial ramifications of a method (studied by Merlini et al., Zeilberger, and others) for enumerating tilings using regular languages. The basic idea is to encode a tiling problem by a finite state machine that generates strings corresponding to valid tilings. We use this technique to derive bijective proofs that certain tiling problems have the same number of solutions. Applications to three-dimensional tilings and other extensions will also be discussed. (Received August 28, 2008)

1046-05-377 **Andrei A. Bulatov*** (abulatov@cs.sfu.ca), School of Computing Science, Simon Fraser University, 8888 University Drive, Burnaby, BC V5A 1S6, Canada. *Counting constraint satisfaction problems.*

The Counting Constraint Satisfaction Problem ($\#CSP(\mathcal{H})$) over a finite relational structure $\mathcal{H}$ can be expressed as follows: given a relational structure $\mathcal{G}$ over the same vocabulary, determine the number of homomorphisms from $\mathcal{G}$ to $\mathcal{H}$. We survey recent results on the complexity of this problem including a characterization of those relational structures $\mathcal{H}$ for which $\#CSP(\mathcal{H})$ can be solved in polynomial time. (Received August 28, 2008)

1046-05-394 **Sven Hermann**, **Anders Jensen**, **Michael Joswig** and **Bernd Sturmfels*** (bernd@math.berkeley.edu), Department of Mathematics, Berkeley, CA 94720. *How to draw tropical planes.*

The tropical Grassmannian parameterizes tropicalizations of linear spaces, while the Dressian parameterizes all planes in $\mathbb{TP}^{n-1}$. We study these parameter spaces and we compute them explicitly for $n \leq 7$. Planes are identified with matroid subdivisions and with arrangements of trees. These representations are used to draw pictures. (Received August 30, 2008)

1046-05-446 **Brad Bailey*** (bbailey@ngcsu.edu), Dept. of Mathematics & Computer Science, 82 College Cr, Dahlonega, GA 30597, and **Dianna Spence** and **John Holliday**. *The r-reduced cutting numbers of cycles, sequences of cycles and graphs.* Preliminary report.

In this talk, we define the r-reduced cutting number of a cycle within a given simple connected graph and the r-reduced cutting number of a graph. We determine the maximum and minimum number of edges in a graph with n vertices and r-reduced cutting number k. We also define the r-reduced cutting number for an edge-wise disjoint sequence of cycles in a graph. Then the cutting power (at level r) of a graph is the shortest such sequence which has r-reduced cutting number at least 2. (Received September 03, 2008)

1046-05-448 **Jason P. Bell*** (jpb@math.sfu.ca), Simon Fraser University, Department of Mathematics, 8888 University Drive, Burnaby, B.C. V5A 1S6, Canada. *Laplace transforms and zero-one laws.* Preliminary report.

We modify Compton's approach to obtaining zero-one laws for various combinatorial structures using Laplace transforms. This new approach allows us to obtain zero-one laws that are much stronger and much more general than those obtained so far by this approach; in particular, this approach unifies much of the existing theory for power series and for Dirichlet series. We also give some applications of this work. (Received September 03, 2008)

1046-05-475 **Timothy B Muller*** (vlmp@iup.edu), 5637 Crimson Hawks, Indiana, PA 15705-5637, and **Kimberly Jordan Burch** (kjburch@iup.edu), 210 South 10th St., Indiana, PA 15668. *Maximally Non-Matching Covered Graphs.*

Let G be a graph. G is said to be matching covered if for every edge e in G, there exists a perfect matching containing e. Infinite families of matching covered graphs are presented and proven. We define a graph to be *maximally non-matching covered* if it contains a unique edge that does not occur in any perfect matching. Conditions for which graphs are maximally non-matching covered are investigated and preliminary results are presented. (Received September 04, 2008)

1046-05-481 **Hong-Jian Lai**, **Liming Xiong** and **Huiya Yan*** (hyan@math.wvu.edu), 320 Armstrong Hall, Dept. of Math, West Virginia University, Morgantown, WV 26506. *Bounded number of components of 2-factors in line graphs.*

A 2-factor is a 2-regular spanning subgraph of a graph G. A lot of results on the components of a 2-factor in G have appeared by studying the conditions on the minimum degree of the graph G. In this paper we avoid studying the minimum degree and get the following: if $\max\{d(x), d(y)\} \geq \dfrac{n-\mu}{p} - 1$ holds for any $xy \notin E(G)$ and $|U| \neq 2$, where $U = \{v : d(v) < \frac{n-\mu}{p} - 1\}$, $p \geq 2$ and μ are two positive integers, then for n sufficiently large relative to p and μ, $L(G)$ has a 2-factor with at most $p+1$ components. Moreover, $L(G)$ has a 2-factor with at most p components if $|U| \leq 1$. This result is best possible. Especially, it extends a result saying that if $\delta(G) \geq \dfrac{n}{p} - 1$, i.e., $U = \emptyset$, then $L(G)$ has a 2-factor with at most p components. We also show the graphs above are $(p+2)$-supereulerian, i.e., have a spanning even subgraph with at most $p+2$ components. (Received September 04, 2008)

1046-05-495 **Carlos Harold Salazar-Lazaro*** (SalazarLazC@gmail.com), 30 North 11th St. Apt 2, San Jose, CA 95112. *Progress on the Skew Hadamard Difference Set existence problem.*

It has been conjectured that the only abelian groups G that admit difference sets D with the skew condition $D + D^{(-1)} = G - [0]$ are the elementary p-abelian groups with an odd number of invariant factors and with $|G| = 3 \bmod 4$. The best progress on this conjecture is in the form of exponent bounds. In the following, we will formulate the existence problem for Generalized Skew Hadamard Difference Sets and extend this conjecture to the case $|G| = 1 \bmod 4$. We will introduce a combinatorial incidence matrix A_{G,G_1} that depends on the structure of G, use this matrix to reformulate the existence conjecture, show the fundamental algebraic equation $A^2_{G,G_1} = \frac{|G|}{p} I$, prove the known exponent bounds using A_{G,G_1} in the language of GSHDSs, and give some existence conditions for the family of groups $G = (Z/pZ) \times (Z/p^2Z)^{2\beta+1}$. (Received September 05, 2008)

1046-05-496 **Albert Atserias*** (atserias@lsi.upc.edu). *Ramsey Theory and Constraint Propagation Heuristics.* Preliminary report.

Bounded consistency algorithms aim at detecting the unsatisfiability of a given system of constraints by propagating constraints of bounded width until some plain contradiction is inferred. An ongoing research programme aims at characterizing which constraint-languages have the property that every unsatisfiable system of constraints is refutable by such methods. An early result along these lines is the characterization of the power of the arc-consistency algorithm due to Feder and Vardi. We offer an alternative characterization of arc-consistency using Ramsey-theoretic methods that looks more amenable to generalization. (Received September 05, 2008)

1046-05-514 **Daniel W Cranston*** (dcransto@gmail.com), DIMACS, CoRE floor 4, Rutgers, 96 Frelinghuysen Road, Piscataway, NJ 08854, and **David Lapayowker**. *Entire $(\Delta+4)$-Choosability of Planar Graphs with $\Delta \geq 8$.*

A plane graph is called entirely k-choosable if, for any list assignment L such that $|L(x)| = k$ for each $x \in V(G) \cup E(G) \cup F(G)$, we can assign each element x a color from its list such that any two elements that are adjacent or incident receive distinct colors. Wang and Lih conjectured that every plane graph is entirely $(\Delta+4)$-choosable, where Δ is the maximum degree. They showed that every plane graph with $\Delta \geq 12$ is entirely $(\Delta+4)$-choosable and that every plane graph with $\Delta \geq 9$ is entirely $(\Delta+5)$-choosable. We improve their results by showing that every plane graph with $\Delta \geq 8$ is entirely $(\Delta+4)$-choosable. (Received September 05, 2008)

1046-05-530 **Alexandra Ovetsky Fradkin*** (aovetsky@math.princeton.edu), Department of Mathematics, Fine Hall, Washington Road, Princeton, NJ 08544-1000, and **Maria Chudnovsky** (mchudnov@columbia.edu). *An approximate version of Hadwiger's conjecture for claw-free graphs.*

Hadwiger's conjecture states that if a graph is not t-colorable then it contains the complete graph on t+1 vertices as a minor. The case t=4 is equivalent to the four color theorem and the case t=5 was proved by Robertson, Seymour, and Thomas with the use of the four color theorem. For t>5, the conjecture remains open. Reed and Seymour have also proved that Hadwiger's conjecture holds for line graphs and in a recent work with Maria Chudnovsky we proved that Hadwiger's conjecture holds for a proper superset of the class of line graphs, known as the class of quasi-line graphs (graphs where the neighbor set of every vertex is the union of two cliques).

A graph is claw-free if it does not have a vertex with three pairwise nonadjacent neighbors. The class of claw-free graphs is a proper superset of the class of quasi-line graphs. In this talk I will outline the proof of a weakened version of Hadwiger's conjecture for claw-free graphs. The proof uses a structure theorem from a recent work of Chudnovsky and Seymour. At the end of the talk I will discuss the progress that has been made on the actual Hadwiger's conjecture for claw-free graphs. This is a joint work with Maria Chudnovsky. (Received September 06, 2008)

1046-05-532 **Anh Vinh Le*** (vinh@math.harvard.edu), 1 Oxford Street, Mathematics Department, Harvard University, Cambridge, MA 02138. *Some combinatorial problems over finite Euclidean and non-Euclidean graphs.*

A classical set of problems in combinatorial geometry deals with the questions of whether a sufficiently large subset of R^d, Z^d or F^d contains a given geometric configuration. Examples are Erdös distance problem, Szemerédi-Trotter theorem and the Furtenberg-Katznelson-Weill theorem. In the finite non-Euclidean spaces, however, the use of known methods, like incidence geometry or Fourier analysis, is nontrivial to the author. We therefore approach the problems using graph theoretic method. Our main tools are graphs associated to the finite Euclidean and non-Euclidean spaces. The advantages of using these graphs are twofold. First, we can reprove and sometimes improve several known results. Secondly, our approach works transparently in the non-Euclidean setting. Due to time constrains, I will only restrict our discussion to a Furtenberg-Katznelson-Weill type theorem and a Szemerédi-Trotter type theorem with its application to sum-product estimate in finite fields. (Received September 06, 2008)

1046-05-533 **Jacob Fox*** (jacobfox@math.princeton.edu), Fine Hall, Washington Road, Princeton, NJ 08544, and **Po-Shen Loh** (ploh@math.princeton.edu) and **Benny Sudakov** (bsudakov@math.ucla.edu). *Large induced trees in K_r-free graphs.*

For a graph G, let $t(G)$ denote the maximum number of vertices in an induced subgraph of G that is a tree. We study the problem of bounding $t(G)$ for graphs which do not contain a complete graph K_r on r vertices. This problem was posed twenty years ago by Erdős, Saks, and Sós. Substantially improving earlier results of various researchers, we prove that every connected triangle-free graph on n vertices contains an induced tree of order $\sqrt{n}$. When $r \geq 4$, we also show that $t(G) \geq \frac{\log n}{4 \log r}$ for every connected K_r-free graph G of order n. Both of these bounds are tight up to small multiplicative constants, and the first one disproves a recent conjecture of Matoušek and Šámal. (Received September 06, 2008)

1046-05-546 **Eric S. Rowland*** (erowland@math.rutgers.edu), Department of Mathematics, Rutgers University, Piscataway, NJ 08854. *Pattern avoidance in binary trees.*

Let T and t be binary trees. We say that T *avoids* t if T does not contain t as a (contiguous) subtree. Counting the number of n-leaf binary trees avoiding t can be done algorithmically, and the resulting generating function is always algebraic. Among the corresponding integer sequences we find the usual suspects (Catalan, Motzkin, etc.). The situation becomes interesting when we look at the analogue of Wilf equivalence — two tree patterns are equivalent if the trees that avoid them are equinumerous (i.e., their generating functions are the same). It is not straightforward to understand the equivalence classes. However, progress can be made with a method of restructuring trees in which all instances of one substructure are turned into another. This approach conjecturally succeeds to produce an explicit bijection for any two equivalent tree patterns. (Received September 07, 2008)

1046-05-574 **Adam Berliner** and **Richard A Brualdi*** (brualdi@math.wisc.ed), Department of Mathematics, University of Wisconsin, 480 Lincoln Drive, Madison, WI 53726, and **Louis Deaett**, **Kathleen P Kiernan**, **Seth Myer** and **Michael Schroeder**. *Signed Domination Number of a Matrix.* Preliminary report.

Let $A = [a_{ij}]$ be an m by n $(0,1)$-matrix (bi-adjacency matrix of a bipartite graph G with a bipartition into sets of sizes m and n). A *signing* of A is a $(0,1,-1)$-matrix $A = [a'_{ij}]$ with the same nonzero pattern as A. The *value* of the signing is $\sum_{ij} a'_{ij}$. The signing A' is called a *dominating signing* provided whenever $a'_{pq} \neq 0$ (that is, $a_{pq} = 1$), we have $a'_{pq} + \sum_{j \neq q} a'_{pj} + \sum_{i \neq p} a'_{iq} \geq 1$. The *signed domination number* of A is the minimum value of a dominating signing of A. We investigate and determine the signed domination number of several classes of matrices, including the m by n matrices J_{mn} of all 1s and $J_{nn} - I_n$. (Received September 08, 2008)

1046-05-588 **Elizabeth Moseman*** (lizz.moseman@usma.edu), US Military Academy, West Point, NY 12518. *Other Critical Exponents in Coordinate Percolation.* Preliminary report.

In coordinate percolation, independent random variables $a_0, a_1, a_2, \ldots, b_0, b_1, b_2, \ldots$ are assigned uniformly on the interal $[0, 1]$. A vertex (i, j) is considered open if $a_i + b_j \leq t$ for a given threshold value t. Previous work by Moseman and Winkler gives an exact function for the the probability of percolation in this scenario. This gives the first critical exponent, concerning the behavior of the probability of percolation above the critical point $t = 1$, as $\beta = \frac{3-\sqrt{5}}{2}$. Specifically, the probability of percolation grows like $(t-1)^\beta$ for t slightly larger than 1. Defining C as the set of all vertices obtainable by open paths from the origin, we define two other critical exponts, δ and γ, concerning the size of C at and below the critical threshold $t = 1$. For δ, the probability of $|C| > n$ is approximately $n^{-1/\delta}$ for large n. For γ, the expected value of $|C|$ is approximately $|t-1|^{-\gamma}$ for t slightly less than 1. Bounds are found for these critical exponents. (Received September 08, 2008)

1046-05-593 **D. Jacob Wildstrom*** (dwildstr@erdos.math.louisville.edu), 328 Natural Sciences Building, Department of Mathematics, University of Louisville, Louisville, KY 40292. *On sums of permutations and sequences with distinct terms.* Preliminary report.

A result of Marshall Hall's demonstrates that for any sequence $\mathbf{b}$ of $n-1$ numbers, there exists an element π of S_{n-1} such that all of the sums $b_i + \pi(i)$ are distinct modulo n. Kézdy and Snevily conjectured that the same holds if $\mathbf{b}$ is of length k and π is in S_k for any $k < n$. The Kézdy-Snevily function $f(n,k)$ is the minimum number of such π ranging over all choices of $\mathbf{b}$. The original conjecture is implied by monotonicity of this function in n and k, and several cases in which monotonicity occurs are presented here. (Received September 08, 2008)

1046-05-721 **Elizabeth Perez Reilly*** (reilly@ams.jhu.edu), The Johns Hopkins University, 3400 North Charles Street, Whitehead Hall, Baltimore, MD 21218, and **Edward R. Scheinerman**. *Random Difference Graphs and Their Properties.*

Difference graphs are graphs such that a threshold, $t \in \mathbb{R}$, and vertex weights $x_1, x_2, \ldots, x_n \in \mathbb{R}$ exist such that $ij \in E(G) \iff |x_i - x_j| > 1$, that is, the weights of i and j are sufficiently far apart. Two equivalent random difference graph models will be developed, one based on the given definition and the other based on the idea of creation sequences for colored difference graphs. Creation sequences will then be used to show some interesting properties of these random difference graphs, such as the probability of sampling a Hamiltonian difference graph or one with a perfect matching. (Received September 10, 2008)

1046-05-734 **Qin Wu*** (qinwu@math.wvu.edu), Department of Mathematics, POBox 6310, West Virginia University, Morgantown, WV 26506, and **Cun-Quan Zhang** and **Eddie Fuller**. *Graph Model for Pattern Recognition in Text.*

In this paper, we propose a novel approach that uses a weighted graph for text pattern recognition. Instead of the traditional model for text classification, we set up a weighted graph model using the distances between the keywords as the weights of edges. And we developed a frequency-distance-based clustering algorithm. One immediate application would be the detection of fraudulent emails as well as the classification of these emails. (Received September 11, 2008)

1046-05-737 **Zachary Bradshaw*** (bradshawz@vcu.edu), 1718 Hanover Ave, Richmond, VA 23220. *Minimum cycle bases of direct products of complete graphs.*

We determine minimum cycle bases of the direct product of the complete graphs K_n and K_2. The problem has previously been solved for $K_m \times K_n$ when $m, n > 2$. We discuss two approaches characterizing these bases. One approach is tailored to the case of $K_n \times K_2$ and gives insight into the cycle space of this class of graphs. Based on the cycles seen in this solution, we illustrate the solution to the more general problem concerning $G \times K_2$ with G an arbitrary connected graph. (Received September 10, 2008)

1046-05-746 **Hillary Einziger*** (hillaryre@gmail.com). *A forest formula for the antipode in incidence Hopf algebras.*

Incidence Hopf algebras can be defined from hereditary families of lattices. The antipode in these Hopf algebras can be computed by summing over all chains of a lattice. We define "forests" of lattices such that there is a surjection from the set of chains of a lattice to the lattice's set of forests, and we define a new formula for the antipode based on summing over these forests. Both Figueroa's (2005) formula for the antipode in the Hopf algebra of distributive lattices and Haiman and Schmitt's (1987) formula for the antipode in the Faa di Bruno Hopf algebra can be seen as examples of this new formula. (Received September 11, 2008)

1046-05-758 **David Joyner***, Math Dept, Chauvenet Hall, US Naval Academy, Annapolis, MD 21402, and **Robert Miller**, University of Washington, Seattle. *Coding theory and combinatorics in Sage.*

This short talk will try to survey some of the functionality in coding theory and combinatorics in Sage. (Received September 10, 2008)

1046-05-763 **Omar A. AbuGhneim*** (o.abughneim@ju.edu.jo), Department of Mathematics, Faculty of Science, Jordan University, Amman, 11942, Jordan, and **Emad E. AbdAlJawad** and **Hasan Al-Ezeh**. *The Clique Number of* $\Gamma(\mathbb{Z}_{p^n}(\alpha))$.

The zero-divisor graph of a commutative ring with one (say R) is a graph whose vertices are the nonzero zero-divisors of this ring, with two distinct vertices are adjacent in case their product is zero. This graph is denoted by $\Gamma(R)$.
We study the zero-divisor graph $\Gamma(\mathbb{Z}_{p^n}(\alpha))$ where p is a prime number, $\mathbb{Z}_{p^n}$ is the set of integers modulo p^n, and $\mathbb{Z}_{p^n}(\alpha) = \{a + bx : a, b \in \mathbb{Z}_{p^n}$ and $x^2 = 0\}$. We find the clique number of $\Gamma(\mathbb{Z}_{p^n}(\alpha))$ and the complete subgraphs of $\Gamma(\mathbb{Z}_{p^n}(\alpha))$ that achieve this clique number. (Received September 11, 2008)

1046-05-794 **John Bowen Polhill*** (jpolhill@bloomu.edu), Department of Mathematics, CS, and Statistics, Bloomsburg University, 400 East Second Street, Bloomsburg, PA 17815. *Paley partial difference sets in groups with order not a prime power.*

By modifying a construction for Hadamard (Menon) difference sets we construct two infinite families of negative Latin square type partial difference sets in groups of the form ${\mathbb{Z}_3}^2 \times {\mathbb{Z}_p}^{4t}$ where p is any odd prime. One of these families has the well-known Paley parameters, which had previously only been constructed in p-groups. This provides new constructions of Hadamard matrices and implies the existence of many new strongly regular graphs. As a corollary, we are able to construct Paley-Hadamard difference sets of the Stanton-Sprott family in groups of the form ${\mathbb{Z}_3}^2 \times {\mathbb{Z}_p}^{4t} \times \mathbb{Z}_{9p^{4t}\pm 2}$ when $9p^{4t} \pm 2$ is a prime power. These are new parameters for such difference sets. (Received September 11, 2008)

1046-05-816 **Andrew G Niedermaier*** (aniederm@math.ucsd.edu), 9500 Gilman Drive, La Jolla, CA 92093-0112. *Extending Generating Functions to* $S_k \wr S_n$.

Ira Gessel was the first to give a multivariate generating function involving the descent, major index, and inversion statistics over the symmetric group S_n in his thesis and in a later paper with Garsia. Mendes and Remmel proved that the Garsia-Gessel formula could be proved by applying a certain ring homomorphism defined on the ring of symmetric functions in infinitely many variable to a simple symmetric function identities and gave analogues for the groups B_n and D_n.

There are several natural ways to extend these formulas to groups of the form of the wreath product of S_k with S_n, $S_k \wr S_n$ for any $k \geq 3$. We give results for generating functions of the above statistics on these groups, and we also describe other statistics than can be obtained by modifying the methods of Mendes and Remmel. (Received September 11, 2008)

1046-05-820 **Georgia Benkart*** (benkart@math.wisc.edu), Department of Mathematics, University of Wisconsin-Madison, 480 Lincoln Drive, Madison, WI 53706-1388, and **Tom Halverson** (halverson@macalester.edu), Department of Mathematics & Computer Science, Macalester College, 1600 Grand Avenue, St. Paul, MN 55105-1899. *Motzkin Algebras and sl(2).*

We introduce a family of diagram algebras, which we call Motzkin algebras, because their dimensions are Motzkin numbers. These algebras arise naturally as the centralizer algebras of sl(2) actions. Subalgebras and simple modules of Motzkin algebras exhibit many beautiful combinatorial properties. This talk will survey some of these topics. (Received September 11, 2008)

1046-05-829 **Jesse T. Geneson*** (jgeneson@fas.harvard.edu). *Extremal Functions of Forbidden Double Permutation Matrices.*

We say a $0-1$ matrix A avoids a pattern P if no submatrix of A can be transformed into P by changing some ones to zeroes. We call P an *m-tuple permutation matrix* if P can be obtained by replacing each column of a permutation matrix with m copies of that column. In this paper, we investigate $n \times n$ matrices that avoid P and the maximum number $ex(n, P)$ of ones that they can have. We prove a linear bound on $ex(n, P)$ for any 2-tuple permutation matrix P, resolving a conjecture of Keszegh (J. Combin. Theory Ser. A (2008), doi: 10.1016/j.jcta.2008.05.006). Using this result, we obtain a linear bound on $ex(n, P)$ for any m-tuple permutation matrix P. Additionally, we demonstrate the existence of infinitely many minimal non-linear patterns, resolving another conjecture of Keszegh from the same paper. (Received September 11, 2008)

1046-05-831 **F. Blanchet-Sadri**, **M. Cordier** and **R. Kirsch*** (rmkirsch@gmail.com). *Combinatorics on Border Correlations of Partial Words.*

Partial words are sequences over a finite alphabet that may contain some "do not know" symbols. In this paper, we consider the border sets of partial words of length n, and study the combinatorics of specific representations of them, called border correlations, which are binary vectors of length n indicating the borders. We characterize precisely which of these vectors are valid border correlations, and establish a one-to-one correspondence between the set of valid border correlations and the set of valid ternary correlations of a given length, the latter being ternary vectors representing the strong and strictly weak period sets. We investigate the population size, that is, the number of partial words sharing a given border correlation, and obtain formulas to compute it. We also give a correspondence between the ternary correlation of a partial word and its refined border correlation, which specifies the lengths of all the word's bordered cyclic shifts' shortest borders. (Received September 11, 2008)

1046-05-836 **Daniel Daly*** (ddaly@du.edu), 2360 S. Gaylord St., Denver, CO 80208. *Reduced Decompositions with Few Repetitions and Permutation Patterns.*

A reduced decomposition of a permutation is a cycle decomposition using only cycles of the form (i, i+1) which is minimal in length. Tenner, Stanley and others have started to connect the study of reduced decompositions with permutation patterns. We will discuss the pattern avoidance and containment conditions for permutations whose reduced decompositions have only one or two elements repeated and connections with the Bruhat order on the symmetric group. Time permitting we will also discuss some new counting results for such permutations. (Received September 12, 2008)

1046-05-837 **Matthias Beck*** (beck@math.sfsu.edu), Department of Mathematics, SFSU, San Francisco, CA 94132, and **Christian Haase** and **Steven Sam**. *Grid graphs, Gorenstein polytopes, and domino stackings.*

We examine domino tilings of rectangular boards, which are in natural bijection with perfect matchings of grid graphs. This leads to the study of their associated perfect matching polytopes, and we present some of their properties, in particular, when these polytopes are Gorenstein. We also introduce the notion of domino stackings and present some results and several open questions. Our techniques use results from graph theory, polyhedral geometry, and enumerative combinatorics. (Received September 12, 2008)

1046-05-859 **Matthew Crawford*** (matthew.crawford@students.olin.edu), Franklin W. Olin College of Engineering, Olin Way, Needham, MA 02492, and **Caitlin Greeley**, **Bryce Lee**, **Mathav Kishore Murugan** and **Sarah Spence Adams**. *Multilevel and Multidimensional Hadamard Matrices.*

Hadamard matrices are square $\{\pm 1\}$ matrices with mutually orthogonal columns, and they have a variety of applications in modern communications systems. We examined generalizations of Hadamard matrices, such as *multilevel* and *3-dimensional (3D)* Hadamard matrices. Multilevel Hadamard matrices allow entries to be any integer. A 3D Hadamard matrix of size $n \times n \times n$ can be viewed as a stack of n 2D Hadamard matrices of size $n \times n$ in which certain substructures must be mutually orthogonal. We looked to combine these ideas into 3D Multilevel Hadamard Matrices (3D MHMs), which we believe to be a new development.

Few constructions for multilevel Hadamard matrices were previously known, none of which could guarantee the desirable property that the constructed matrix contains n distinct integer entries, each appearing exactly once per column. We discovered a construction technique for $n \times n$ multilevel Hadamard matrices which guarantees this property for all n. We also proved the existence of $n \times n \times n$ 3D MHMs by discovering a method to construct 3D MHMs from 2D multilevel Hadamard matrices. We expect that these orthogonal matrices may prove useful in communications systems, as their 2D analogs already have. (Received September 12, 2008)

1046-05-868 **Kim A.S. Factor**, Marquette University, Milwaukee, WI 53201, and **Larry J. Langley***, University of the Pacific, Stockton, CA 95211. *Secondary Domination Graphs of Tournaments.*

We adapt a definition for secondary domination by Hedetniemi et.al. to directed graphs. In particular we consider the $(1,2)$-domination graph of tournaments. Given a directed graph D, two vertices x and y form a $(1,2)$-dominating pair if and only if, for any other vertex in the graph z, you can reach z in at most one step from one of x or y and in at most two steps from the other vertex. A $(1,2)$-domination graph on the vertex set of D has edge xy if and only if x and y are a $(1,2)$-dominating pair of D. We examine the structure of $(1,2)$-domination graphs of tournaments. (Received September 12, 2008)

1046-05-874 **Stephen Hartke** (hartke@unl.edu), Department of Mathematics, University of Nebraska - Lincoln, 203 Avery Hall, Lincoln, NE 68588, and **Geir Helleloid*** (geir@math.utexas.edu), Department of Mathematics, The University of Texas at Austin, 1 University Station, C1200, Austin, TX 78712. *Reconstructing a Graph from its Vertex-Edge Incidence Graph.*

Brualdi and Massey introduced the incidence coloring number of a graph in order to study the strong chromatic index of multigraphs. The incidence coloring number of a graph G can be defined as the chromatic number of the vertex-edge incidence graph of G. The vertex-edge incidence graph is reminiscent of the line graph, and much work has been done on structural characterizations and recognition algorithms for line graphs. In this talk, we focus on an analogous recognition algorithm for vertex-edge incidence graphs that also allows the reconstruction of a graph from its vertex-edge incidence graph in O(m) steps, where the vertex-edge incidence graph has m edges. (Received September 12, 2008)

1046-05-880 **Michael D Barrus*** (mbarrus2@illinois.edu), Department of Mathematics, University of Illinois, Urbana, IL 61801, and **Douglas B West** (west@math.uiuc.edu), Department of Mathematics, University of Illinois, Urbana, IL 61801-2975. *On A_4-balanced graphs.*

The A_4-structure of a graph G is the 4-uniform hypergraph H on $V(G)$ whose edges consist of vertex subsets inducing $2K_2$, C_4, or P_4 in G. We define G to be A_4-balanced if the vertices of G may be partitioned into two subsets such that each hyperedge in H has two vertices in each subset; thus the class of A_4-balanced graphs contains all graphs which have the same A_4-structure as a split or bipartite graph. We survey results on A_4-balanced graphs and the similarly defined P_4-balanced graphs and give characterizations of the A_4-split and A_4-bipartite graphs. (Received September 12, 2008)

1046-05-888 **Todd M. Gutekunst*** (toddgutekunst@kings.edu). *Subsets of finite groups exhibiting additive regularity.*

We introduce the combinatorial notion of additive regularity and investigate sets that are as additively regular as possible. The study of these sets provides a companion to the more-familiar theory of (v, k, λ)-difference sets. We will present several explicit constructions for additively regular sets and several powerful nonexistence results. (Received September 12, 2008)

1046-05-936 **Lara K. Pudwell*** (Lara.Pudwell@valpo.edu), Department of Mathematics & Computer Science, 1900 Chapel Drive, Valparaiso, IN 46383. *Enumeration Schemes for Barred Permutation Patterns.* Preliminary report.

Barred patterns are a generalization of permutation patterns which characterize 2-stack sortable permutations, forest-like permutations, and other combinatorial objects. I will introduce the notion of barred patterns and show how to use Maple to derive recurrences for the counting sequences of permutations avoiding certain barred patterns. (Received September 12, 2008)

1046-05-979 **Anne C. Sinko*** (Anne.Sinko@oberlin.edu), 211 Rice Hall, Oberlin, OH 44074. *$\mathcal{R}$-parametric Chains.*

The standard, well-studied, well-known chain of parameters $\mathrm{ir}(G) \leq \gamma(G) \leq \mathrm{i}(G) \leq \beta(G) \leq \Gamma(G) \leq \mathrm{IR}(G)$ arises from the observations that an independent set is maximally independent if and only if it is dominating, and a dominating set is minimally dominating if and only if it is irredundant. Observe that these parameters are defined relative to the edge set $E(G)$. By considering two natural extensions of independence and varying the collection $\mathcal{R} = \{R_1, R_2, ..., R_t\}$ of subsets of the vertex set relative to which these notions of "independence" are defined results in several generalized $\mathcal{R}$-parametric chains. (Received September 13, 2008)

1046-05-986 **Suman Balasubramanian*** (sb333@msstate.edu), Department of Mathematics and Statistics, Mississippi State University, Mississippi State, MS 39762-9715, and **Edward Dobson** (dobson@math.msstate.edu), Department of Mathematics and Statistics, Mississippi State University, Mississippi State, MS 39762-9715. *On the Erdos- Sos and Komlos Sos Conjecture for graphs without a K(2,s).*

Let $s > 2$ be an integer and $k > 12(s-1)$ an integer. We give a necessary and sufficient condition for a graph G containing no $K_{2,s}$ with and to contain every tree T of order $k+1$. We then show that every graph G with no $K_{2,s}$ and average degree greater than $k-1$ satisfies this condition, improving a result of Haxell, and verifying a special case of the Erdös - Sós conjecture, which states that every graph of average degree greater than $k-1$ contains every tree of order $k+1$. We also give some preliminary results on the Komlos- Sós Conjecture that states that *Let k be a positive integer. If at least half the vertices of a graph G have degree at least k, then G contains as subgraphs all trees of size k.* (Received September 13, 2008)

1046-05-997 **Nora Youngs*** (nyoungs@email.smith.edu), Smith College, Department of Mathematics and Statistics, Northampton, MA 01063, and **Carolyn Gardner**, **Marissa Neal**, **Yoshi Merrybird** and **Agnieszka Rec**. *Coloring Graphs.* Preliminary report.

Two colorings of a graph, G, are isomorphic if by permuting the colors in one of them, we can obtain the other. The set of nonisomorphic colorings of G is the set of isomorphism classes of proper colorings. Define the graph of nonisomorphic colorings of G, I(G), to have vertex set equal the set of nonisomorphic colorings of G, with an edge between two colorings if they are isomorphic on V(G-x) for some x in V(G). Similarly, define the graph of canonical colorings of G, Can(G) on the same set of vertices, but with an edge between two colorings if they are identical on V(G-x). In this talk we explore properties of I(G) and Can(G). (Received September 13, 2008)

1046-05-1042 **Craig Larson*** (clarson@vcu.edu), VCU Dept. of Mathematics, Oliver Hall, 1001 W. Main Street, P.O. Box 842014, Richmond, VA 23284-2014. *The Critical Independence Number of a Graph and an Independence Decomposition.*

The critical independence number of a graph is the cardinality of a maximum independent set I, where $|I| - |N(I)| \geq |J| - |N(J)|$, for any independent set J. This number is a lower bound for the independence number and can be computed in polynomial-time. Any graph can be decomposed into two subgraphs where the independence number of one subgraph equals its critical independence number, where the critical independence number of the other subgraph is zero, and where the sum of the independence numbers of the subgraphs is the independence number of the graph. (Received September 14, 2008)

1046-05-1048 **Zhongyuan Che*** (zxc10@psu.edu), Department of Mathematics, 100 University Dr., Penn State Beaver, Monaca, PA 15061, and **Zhibo Chen** (zxc4@psu.edu), Department of Mathematics, 4000 University Drive, Penn State Greater Allegheny, Mckeesport, PA 15132. *Forcing faces in plane bipartite graphs.*

A finite face s of a 2-connected plane bipartite graph G is said to be a forcing face of G if the subgraph of G obtained by deleting all vertices of s together with their incident edges has exactly one perfect matching. We prove that any connected plane bipartite graph with a forcing face is elementary, and for any integers n and k with $n \geq 4$ and $n \geq k \geq 0$, there exists a plane elementary bipartite graph such that exactly k of the n finite faces of G are forcing. On the other hand, any connected cubic plane bipartite graph has no forcing faces. Using the tool of Z-transformation graphs, we characterize the plane elementary bipartite graphs whose finite faces are all forcing. We also obtain a necessary and sufficient condition for a finite face in a plane elementary bipartite graph to be forcing, which enables us to investigate the relationship between the existence of a forcing edge and the existence of a forcing face in a plane elementary bipartite graph, and find out that the former implies the latter but not vice versa. Moreover, we characterize the plane bipartite graphs that can be turned to have all finite faces forcing by subdivisions. (Received September 14, 2008)

1046-05-1065 **Bill Kay*** (kayw@mailbox.sc.edu), 1400 Greene Street, PO Box 80941, Columbia, SC 29225, and **Greg Brockman** (gbrockm@fas.harvard.edu). *Elementary Techniques for Erdos-Ko-Rado-like Theorems.*

The well-known Erdos-Ko-Rado Theorem states that if F is a family of k-element subsets of $1, 2, ..., n (n \leq 2k-1)$ such that every pair of elements in F has a nonempty intersection, then the size of F is at most $\binom{n-1}{k-1}$. The theorem also provides necessary and sufficient conditions for attaining the maximum. We present elementary methods for deriving generalizations of the Erdos-Ko-Rado Theorem on several classes of combinatorial objects. We also extend our results to systems under Hamming intersection. (Received September 14, 2008)

1046-05-1069 **Matthew Macauley*** (mmacaul@clemson.edu), Department of Mathematical Sciences, O-325 Martin Hall, Clemson University, Clemson, SC 29634-0975, and **Brian Rabern** and **Landon Rabern**. *Semantic paradoxes and graph dynamical systems.* Preliminary report.

We present a mathematical foundation to study semantic paradoxes using graph theory and local binary functions. In this setting, a paradox is represented by a particular graph dynamical system that has no fixed points. Most work on the nature of paradox has used tools from symbolic logic, whereas our goal is to completely characterize paradox from purely a graph-theoretic point of view. Our work to tackle this problem draws from the rich structure of graph theory, real analysis, and algebraic geometry, and in this talk, we will present some of our results and outline some future goals. (Received September 14, 2008)

1046-05-1085 **Venkatesan Guruswami***, venkat@cs.washington.edu. *Coding theory and Pseudorandomness.*

There is a rich interplay between coding theory and computational complexity theory that has enriched both disciplines over the years. In particular, error-correcting codes have been instrumental in several advances in the subject of pseudorandomness, leading to explicit constructions of objects (such as expander graphs, randomness extractors, pseudorandom generators, etc.) with desirable properties similar to those achieved by random objects.

This talk will survey some recently discovered interconnections between coding theory and pseudorandomness, including the construction of lossless expanders from a variant of Reed-Solomon codes, and the construction of

Euclidean sections and compressed sensing matrices from expander codes. We will also mention some coding-theoretic challenges for derandomization, resolving which will lead to explicit codes with important properties. (Received September 14, 2008)

1046-05-1168 **Kyle Pula*** (jpula@math.du.edu). *The Hall-Paige conjecture in non-associative contexts.*
The recently established Hall-Paige conjecture says that for a finite group G the following are equivalent:

(1) the multiplication table of G (considered as a Latin square) has a transversal,

(2) Sylow 2-subgroups of G are trivial or non-cyclic,

(3) and there is an ordering of G such that $g_1 \cdots g_n = 1$.

We propose non-associative analogues for these conditions and establish several implications between the proposed conditions. (Received September 15, 2008)

1046-05-1184 **Tariq A Alraqad*** (tariq.alraqad@northern.edu), Mathematics Department, Northern State University, 1200 S. Jay st., Aberdeen, SD 57401, and **Mohan Shrikhande**.
Non-embeddable Quasi-residual Menon Designs.
A Menon design of order h^2 is a symmetric $(4h^2, 2h^2-h, h^2-h)$-design. Quasi-residual and quasi-derived designs of a Menon design have parameters 2–$(2h^2+h, h^2, h^2-h)$ and 2–$(2h^2-h, h^2-h, h^2-h-1)$ respectively. We give a new method to construct non-embeddable quasi-residual and quasi-derived Menon designs using regular Hadamard matrices. As applications, we construct the first two new infinite families of non-embeddable quasi-residual and quasi-derived Menon designs. (Received September 15, 2008)

1046-05-1212 **Li Chen*** (lchen@udc.edu), 4200 Connecticut Ave, N.W., Department of Computer Science and IT, University of the District of Columbia, Washington, DC 20008.
Error-Correction Coding using Combinatorial Representation Matrices.
This talk will start with the optimum SEC-DED (Hamming) code, the Hsiao code. We will use a recursive method to generate the (0,1)-check matrix of the code to meet the requirement of each column contains the same odd-number of 1's and each row contains the same number of 1's or differs at most by one for the number of 1's. We will also show that the algorithm based on our method attained optimum in average cases if a divide-and-conquer technique must be involved in the algorithm. We then introduce a general method based on Combinatorial matrices for other coding problems such as two problems related to the set of k linearly independent vectors over $GF(2^b)$. We finally will study the relationship between such a coding method with scheduling problems in the real world. (Received September 15, 2008)

1046-05-1220 **Martin J. Erickson*** (erickson@truman.edu), Department of Mathematics and Computer Scienc, Truman State University, Kirksville, MO 63501. *Enumerating Rook Paths and Queen Paths.* Preliminary report.
How many ways can a chess Rook or Queen move from a corner cell to the opposite corner cell of an arbitrary size, arbitrary dimensional chess board, assuming that the piece moves with monotonically increasing coordinates at each step? Recurrence relations, generating functions, and asymptotic formulas are given for the number of paths. Also, some open problems are presented. (Received September 15, 2008)

1046-05-1226 **Futaba Okamoto*** (okamoto.futa@uwlax.edu), University of Wisconsin - La Crosse, Mathematics Dept., 1725 State St., La Crosse, WI 54601, and **Gary Chartrand** (gary.chartrand@wmich.edu) and **Ping Zhang** (ping.zhang@wmich.edu). *The Rainbow Index of a Graph.*
An edge-colored tree T is a rainbow tree if no two edges of T are colored the same. For a connected graph G of order $n \geq 3$ and an integer k with $2 \leq k \leq n$, a k-rainbow coloring of G is an edge coloring having the property that for every set S of k vertices of G, there is a rainbow tree T containing the vertices of S. The minimum number of colors needed in a k-rainbow coloring of G is the k-rainbow index of G. This topic is discussed and some results are presented. (Received September 15, 2008)

1046-05-1250 **Andre E. Kezdy*** (kezdy@louisville.edu), Department of Mathematics, University of Louisville, Louisville, KY 40292, and **Adam Jobson**, Department of Mathematics, University of Louisville, Louisville, KY 40292. *Some observations on sorting pairs in bins.* Preliminary report.
This talk will summarize some observations we have made toward solving the mathematical puzzle Peter Winkler calls the problem of "Sorting Pairs in Bins:" Imagine n bins in a row each containing two labeled balls, the ith bin containing balls labeled $n+1-i$. A move consists of swapping two balls between consecutive bins. How many moves are needed to get each ball into the bin with its label? (Received September 15, 2008)

1046-05-1262 **Ken Shoda*** (kenshoda@gwu.edu), 1628 Massachusetts Ave SE, Washington, DC 20003.
Super-exponential families of nonisomorphic matroids having the same Tutte polynomial.

Omer Giménez showed how to construct, for each permutation of $[n]$, a matroid on $4n+5$ elements so that all $n!$ resulting matroids are nonisomorphic but have isomorphic lattices of cyclic flats of width 2. We show that these matroids in fact have the same Tutte polynomial. Thus, this gives a super-exponential family of nonisomorphic matroids having isomorphic lattices of cyclic flats and the same Tutte polynomial. (Received September 15, 2008)

1046-05-1278 **James N Brantner*** (jbrantne@erskine.edu), PO Box 1001, CPO 229, Due West, SC 29639. *On Seymour's Second Neighborhood Conjecture.*

Let D be a simple digraph without loops or digons (i.e. if $(u,v) \in E(D)$, then $(v,u) \notin E(D)$). For any $v \in V(D)$ let $N_1(v)$ be the set of all vertices at out-distance 1 from v and let $N_2(v)$ be the set of all vertices at out-distance 2. We provide sufficient conditions under which there must exist some $v \in V(D)$ such that $|N_1(v)| \leq |N_2(v)|$, as well as examine properties of a minimal graph which does not have such a vertex. We show that if one such graph exists, then there exist infinitely many strongly-connected graphs having no such vertex. (Received September 15, 2008)

1046-05-1281 **Philip Matchett Wood*** (matchett@math.rutgers.edu), Department of Mathematics, Rutgers University, Hill Center for the Mathematical Sciences, 110 Frelinghuysen Rd., Piscataway, NJ 08854, and **Linh Tran** and **Van Vu**. *Structure and Randomness in Additive Combinatorics.*

In this talk, we will discuss the dichotomy between structure and randomness and the roll it plays in recent work on a few problems in additive combinatorics. Two problems that will be discussed are (1) demonstrating that the cardinality of $A \widehat{+} A := \{a+b : a, b \in A \text{ and } a \neq b\}$ is small only when A is close to an arithmetic progression (this is the inverse Erdős-Heilbronn problem) and (2) proving a conjecture due to Noga Alon that determines, for integers $n \leq m \leq n^2$, just how dense a subset $A \subset \{1, 2, \ldots, n\}$ must be so that m can be represented as a sum of distinct elements of A. For both of these problems, we will discuss a sense in which either a common case occurs and the behavior is essentially random, or a rare case occurs and the behavior is highly structured. This common thread of separating the structured and random cases has lead to recent results for both problems. Joint work with Linh Tran and Van Vu. (Received September 15, 2008)

1046-05-1294 **Jonathan Cutler*** (jonathan.cutler@montclair.edu), Department of Mathematical Sciences, Montclair State University, Montclair, NJ 07043, and **A J Radcliffe**. *Entropy inequalities.*

In this talk, we will present some new entropy inequalities and their applications to graph theory. (Received September 15, 2008)

1046-05-1352 **Camillia Smith*** (cammie@math.harvard.edu), Harvard University Department of Mathematics, 1 Oxford St, Cambridge, MA 02138. *Enumeration of the distinct shuffles of permutations.* Preliminary report.

A shuffle of two words is a word obtained by concatenating the two original words in either order and then sliding any letters from the second word back past letters of the first word, in such a way that the letters of each original word remain spelled out in their original relative order. Examples of shuffles of the words $abcd$ and $efgh$ are, for instance, $aebcfghd$ and $eabcfgdh$. In this paper, I enumerate the distinct shuffles of two permutations of any two lengths, where the permutations are written as words in the letters $1, 2, 3, ..., m$ and $1, 2, 3, ..., n$, respectively. (Received September 15, 2008)

1046-05-1376 **Mark Ellingham**, **Michael Plummer** and **Gexin Yu*** (gyu@wm.edu), Department of Mathematics, College of William and Mary, Williamsburg, VA 23185. *some results on graph linkage.* Preliminary report.

For a multigraph H, a graph G is H-linked if for every injective mapping $f : v(H) \to V(G)$, there is an H-subdivision with branch vertex set $f(V(H))$. This notion generalizes k-connected, k-linked and k-ordered.

We will discuss results on H-linkage when H has at most four vertices. (Received September 15, 2008)

1046-05-1400 **Fan Chung** and **Paul K Horn*** (phorn@math.ucsd.edu), 9500 Gilman Drive # 0112, La Jolla, CA 92093-0112, and **Linyuan Lu**. *The diameter of random spanning trees in a given graph.*

We study the diameter of a uniform spanning tree in a general graph with bounded spectral gap of the normalized Laplacian. In the case of complete graphs, this problem has been well studied with Rényi and Szekeres showing that the height has order $\sqrt{n}$ with high probability. Aldous later studied the problem for d-regular graphs. Here, we consider general graphs with no regularity assumptions. We show the diameter of a random spanning is between $c\sqrt{n}$ and $c'\sqrt{n}$ with c depending on the spectral gap and moments of the degree sequences. Furthermore, in the lower bound we improve the bound of Aldous for regular graphs by a factor of $\log n$. (Received September 15, 2008)

1046-05-1406 **Jeremy M. Aikin*** (jaikin@math.lsu.edu), Mathematics Department, Louisiana State University, Baton Rouge, LA 70803-4918, and **James Oxley** (oxley@math.lsu.edu), Mathematics Department, Louisiana State University, Baton Rouge, LA 70803-4918. *Towards a general tree decomposition theory for matroids.*

Oxley, Semple and Whittle described a tree decomposition for a 3-connected matroid M that displays, up to a natural equivalence, all non-trivial 3-separations of M. Crossing 3-separations gave rise to fundamental structures known as flowers. In this talk, we show that crossing separations of higher order also have a flower-like structure and we illustrate the kinds of structures that can arise by considering certain subsets of a vector space. (Received September 15, 2008)

1046-05-1457 **Emma E. Snively*** (snivelee@rose-hulman.edu), RHIT CM 821, 5500 Wabash Ave, Terre Haute, IN 47803, and **Bill Kay** (kayw@mailbox.sc.edu) and **Greg Brockman** (gbrockm@fas.harvard.edu). *Universal Cycles on Simple Graphs.*

A universal cycle of combinatorial objects is the smallest possible cyclic representation of all objects in a class. For example, 0011 is a universal cycle of 2-letter binary words because it contains each of 00, 01, 11, 10 exactly once. We explore the properties of universal cycles of simple graphs on n vertices. (Received September 15, 2008)

1046-05-1506 **William M Ella*** (wella9cd@umw.edu), 1914 Cambridge Drive, Vinton, VA 24179, and **Michael L Follett**, **Chelsey A Cooley**, **Eric A Gilson** and **Lorenzo Traldi**. *Generalized Dice: An Investigation of Dice Families.* Preliminary report.

A generalized die is an ascending list of integers; we think of the integers in the list as labels appearing on the "sides" of the die. A die X is stronger than a die Y if there are fewer pairs (i, j) with $x_i < y_j$ than pairs (i, j) with $x_i > y_j$; if neither of X, Y is stronger than the other then X and Y are tied. A dice family $D(n, a, b, s)$ contains all n-sided dice whose labels lie between a and b and sum to s. We discuss interesting experimental results concerning the overall tie density in a family, and the percentage of dice that tie over half of their "siblings." Families of four-sided dice have unusually high tie percentages. We also explore theoretical results concerning weakly balanced dice, which have equal numbers of wins and losses, and symmetric dice, which have a palindromic label structure; these two initially very different sounding subsets turn out to be closely related. We also discuss experimental results related to other open questions regarding dice families. (Received September 15, 2008)

1046-05-1521 **Jaewoo Lee*** (jlee@bmcc.cuny.edu), Department of Mathematics, Borough of Manhattan Community College(CUNY), 199 Chambers Street, New York, NY 10007. *Growth of sumsets and polytopes.*

Ever since Milnor asked about growth of groups, growth functions have been actively studied. In this talk, we will investigate how sumsets of a finite set of lattice points grow as geometric objects. Especially, we will see that sumsets grow basically as dilations of the set's convex hull. (Received September 16, 2008)

1046-05-1539 **Karen L Collins*** (kcollins@wesleyan.edu), Dept. of Mathematics and Computer Science, Wesleyan University, Middletown, CT 06459-0128. *The Distinguishing Chromatic Number.*

Collins and Trenk introduced the distinguishing chromatic number of a graph G, $\chi_D(G)$, as the minimum number of colors needed to color the vertices so that

(1) the coloring is a proper graph coloring and

(2) the only automorphism of the graph which preserves colors is the identity.

Thus the distinguishing chromatic number is closely related to both the chromatic number,$\chi(G)$, and the distinguishing number, $D(G)$ (introduced by Albertson and Collins), of a graph. It is straightforward to see that

$$\chi(G), D(G) \leq \chi_D(G) \leq \chi(G) \cdot D(G)$$

and that the lower bounds are tight. In this talk, we will present infinite families of graphs that achieve the upper bound, and, in contrast, families of graphs with an upper bound on χ_D that depends instead on the automorphism group of the graphs. (Received September 15, 2008)

1046-05-1543 **David E Brown**, Department of Mathematics, Utah State University, **Arthur H Busch**, Department of Mathematics, University of Dayton, and **Garth Isaak*** (gisaak@lehigh.edu), Department of Mathematics, Lehigh University. *Structure of Bipartite Probe Interval Graphs.*

Probe interval graphs, originally motivated by an application in biological sequencing are a special class of interval tolerance graphs. Interval tolerance graphs have representations with each vertex assigned an interval and a tolerance with an edge between vertices exactly when the length of the intersection of their intervals is at least the smaller of the two tolerances. For probe interval graphs the only allowed tolerances are zero and infinity. Building on previous results for bipartite tolerance graphs we present a linear algorithm to recognize if a given bipartite graph is a probe graph and discuss a corresponding structural characterization.

We will in addition provide a brief overview of some other interesting results and open problems relating to tolerance graphs. (Received September 16, 2008)

1046-05-1558 **Jeffrey A Mudrock*** (mudrock2@uiuc.edu), **Saad El-Zanati**, **Kyle King** and **Josephine Witkowski**. *On decomposing complete graphs of odd order into Hamilton cycles and fixed length cycles.*

Let $k \geq 3$, $x \geq 1$, and $t \geq 0$ be integers. We show that there exists a cyclic C_k-decomposition of $K_{2kx+2t+1} - H$, where H consists of t Hamilton cycles. (Received September 16, 2008)

1046-05-1610 **Garry S Bowlin*** (bowlin@math.binghamton.edu), Binghamton University, Dept. of Mathematics, Bingahmton, NY 13902-6000. *The Gale-Berlekamp Switching Game.* Preliminary report.

The Gale-Berlekamp Switching Game consists of an $n \times n$ grid of lights, with switches for each row and column, and a subset S of lights which are initially on. When a switch is thrown, all lights in the corresponding row or column change states. The goal of the game is to turn off as many lights as possible. The question is: at the end of the game, what is the maximum number of lights that are still on, over all possible starting sets S? My research focuses on this question and the generalization to an $m \times n$ grid. I study the problem by looking at the adjacency matrix of a signed complete bipartite graph that corresponds to the initial configuration, and asking what are the possible final configurations. This results in a polytope of final configurations, and using integer programming, the maximum number of lights can be found. (Received September 16, 2008)

1046-05-1653 **richard b freeman***, 1050 nber, 1050 mass avenue, cambridge, MA 02138. *Will contiguous redistricting create competitive races for legislative elections?*

Most plans that call for redistricting to create more competitive races for the House of Representatives seek to change boundaries in contiguous ways that do not resemble classic gerrymandering. However, because people of similar income or ethnicity tend to live in the same areas, there would be surprisingly little improvement in competitiveness from almost any plausible redistricting scheme that follows reasonable geographic bounds. This suggests that something beyond redistricting is needed to create greater competitiveness in political races. (Received September 16, 2008)

1046-05-1658 **Xiaofeng Wang*** (alexwang@math.wvu.edu), West Virginia University, Department of Mathematics, Morgantown, WV 26506. *Fulkerson Coloring of Some Families of Snarks.*

The Fulkerson Conjecture states that every cubic bridgeless graph has six perfect matchings such that every edge of the graph is contained in exactly two of these perfect matchings. In this paper, a useful technical lemma is proved. This lemma is further applied in the verification of Fulkerson conjecture for some families of snarks (Goldberg snarks, flower snarks). (Received September 16, 2008)

1046-05-1712 **Ryan Bunge*** (rc_bunge@hotmail.com), **Saad El-Zanati** and **Charles Vanden Eynden**. *On γ-labeling almost-bipartite 2-regular graphs.*

An *almost-bipartite* graph G is a non-bipartite graph with an edge e such that $G - e$ is bipartite. Let G be a graph with n edges. In the mid 1960's Alex Rosa introduced certain labelings of G that yielded cyclic G-decompositions of K_{2n+1}. When G is bipartite, certain labelings of G yielded cyclic G-decompositions of K_{2nx+1} for every positive integer x. In 2004, Blinco et al introduced a labeling for almost-bipartite graphs G that yielded cyclic G-decompositions of K_{2nx+1}. We show that every 2-regular almost-bipartite graph other than C_3 and $C_3 \bigcup C_4$ admits a γ-labeling. (Received September 16, 2008)

1046-05-1723 **Sebastian H Moore*** (smoore@haverford.edu), Haverford College, 370 Lancaster Ave., Haverford, PA 19041, and **Sonia Gilbukh** and **Lynne M. Butler** (lbutler@haverford.edu). *An Injective Proof of Strong q-Log-Convexity for Bell Polynomials.*

While it has been known for some time that Bell numbers are log convex, a simple case of q-log-convexity for Bell polynomials was proved in 2006 by Liu and Wang. This summer has seen the proof of the general case by Chen, Wang and Yang using methods similar to Liu and Wang. Here we take the approach of Butler and Flanigan to give an injective proof of the result. (Received September 16, 2008)

1046-05-1749 **Christoph Koutschan*** (ckoutsch@risc.uni-linz.ac.at), RISC, Johannes Kepler University, Altenberger Str. 69, 4040 Linz, Austria. *Towards a proof of the q-TSPP conjecture.*

The study of totally symmetric plane partitions (TSPP) has attracted the attention of famous combinatorialists for years. While the conjectured formula about the number of TSPPs was proven in 1995 by Stembridge, its q-analog (conjectured by Andrews and Robbins) is still open and one of the most outstanding problems in enumerative combinatorics. We demonstrate how computer algebra methods can be used in order to tackle this kind of problems. (Received September 16, 2008)

1046-05-1752 **Qing Xiang*** (xiang@math.udel.edu), Department of Mathematical Sciences, University of Delaware, Newark, DE 19716. *Modular ranks of the adjacency matrices of strongly regular graphs arising from semifields.*

A construction of strongly regular graphs (srg) was given recently by Weng, Qiu, Wang and Xiang. The srg constructed in this way have the same parameters as those of the Paley graphs. One possible way to show that the srg from semifields are not isomorphic to the Paley graphs is to compute the p-ranks of the adjacency matrices involved. The sizes of these adjacency matrices grow very large and the matrices are dense. In this talk we will discuss the construction of the srg and the computations of p-ranks of the adjacency matrices by Saunders and collaborators. (Received September 16, 2008)

1046-05-1782 **Marshall M Cohen*** (marshall.cohen@morgan.edu), Department of Mathematics, Morgan State University, 1700 East Cold Spring Lane, Baltimore, MD 21251. *Elements of Finite Order in the Riordan Group.*

Suppose that D is an integral domain of characteristic zero and D^* is the group of units in $D-\{0\}$. The **Riordan group** over D, denoted $\mathcal{R}(D)$. is the set of ordered pairs (g,f) of formal power series over D where $g(z)=\sum_{n=0}^{\infty} g_n z^n \quad f(z)=\sum_{n=1}^{\infty} f_n z^n, \quad g_0, f_1 \in D^*$, The operation is a combination of series multiplication and formal composition of series (substitution) given by

$$(g,f)(G,F)=(g\cdot(G\circ F), F\circ f)$$

Theorem: If (g,f) has finite order in $\mathcal{R}(D)$ then order(g,f) is the least common multiple of the orders of g_0 and f_1 in D^*.

Corollary: The order of an element of finite order in the Riordan group over $\mathbb{R}$ (or $\mathbb{Q}$ or $\mathbb{Z}$) is either one or two. (Received September 16, 2008)

1046-05-1811 **John P. Georges** and **David W. Mauro*** (david.mauro@trincoll.edu), Math Dept, Trinity College, Hartford, CT 06106, and **Yan Wang**. *Further results on labeling the r-path with a condition at distance two.*

For integers $1\le k\le j$, an $L(j,k)$-labeling of simple graph G is a vertex labeling such that vertices at distance 1 (resp. 2) receive labels that differ by at least j (resp. k). The r-path on $n\le\infty$ vertices $v_0, v_1, ..., v_{n-1}$ is the graph $P_n(r)$ such that v_x and v_y are adjacent iff $1\le|x-y|\le r-1$. Since $P_n(r)$ is a natural representation of transmitters (vertices) deployed along a straight line such that the distance between transmitters is given by the distance between corresponding vertices, it is equally natural to approach the problem of economical frequency assignment to the transmitters by considering the minimum span $\lambda_{j,k}(P_n(r))$ over the collection of $L(j,k)$-labelings of $P_n(r)$. In this paper, we discuss techniques for establishing $\lambda_{j,k}(P_n(r))$ for various n, r, j, and k, including techniques that have emerged from results on the infinite r-regular tree and the piecewise linearity of $\lambda_{x,1}(G)$, the natural extension of $\lambda_{j,k}(G)$ from positive integer j to real non-negative x. Open questions are posed. (Received September 16, 2008)

1046-05-1812 **Daniel Schaal*** (daniel.schaal@sdstate.edu), Dept. of Mathematics and Statistics, South Dakota State University, Brookings, SD 57007, and **Mike Bergwell** and **Scott Jones**. *Selectivity Schur Numbers for a Finite Number of Colors.*

In 1916, I. Schur proved the following theorem. For every integer t greater than or equal to 2, there exists a least integer n = S(t) such that for every coloring of the integers in the set 1, 2, ... , n with t colors there exists a monochromatic solution to x + y = z. This equation is called the Schur equation and the integers S(t) are called Schur numbers and are known only for t = 2, t = 3 and t = 4. This problem can be modified by also considering solutions where the three integers in the solution are all colored different colors, known as a totally multicolored solution (also known as a polychromatic or rainbow solution). A solution that is either monochromatic or totally multicolored is called a selectivity solution. It has long been known that if an infinite number of colors are used, it is possible to color the entire set of natural numbers and avoid a selectivity solution to the Schur equation. In this paper we find the longest colorings that avoid selectivity solutions to the Schur equation for any finite number of colors. (Received September 16, 2008)

1046-05-1842 **Katherine D. Crowley** (crowleyk@wlu.edu), Washington and Lee University, Department of Mathematics, Lexington, VA 24450, and **Abigail Ebin** and **Bena M. Tshishiku*** (tshishikub@wlu.edu), P.O. Box 392, Lexington, VA 24450. *Minimal Triangulations of Contractible Spaces and Random Collapsing of n-simplices.* Preliminary report.

Collapsing is a combinatorial analog of contractibility for smooth spaces. Many problems in topology and combinatorics reduce to analyzing a simplicial complex, and in particular whether the complex collapses to a point. In practice, checking for collapsibility can be computationally intensive if the order in which one collapses affects the outcome. While it is straightforward to find a way to collapse any n-simplex to a point, it is less obvious whether one can perform collapses in a different order and get "stuck", with no more available collapses, before arriving at a single point. Previously, Crowley and Ebin showed that if $n \geq 7$, then it is possible to collapse an n-simplex to the dunce hat or Bing's house with two rooms, neither of which can be collapsed further. We will answer the question for $n \leq 6$. (Received September 16, 2008)

1046-05-1889 **Vladimir Nikiforov*** (vnikifrv@memphis.edu). *The number of cliques in graphs of given order and size.*

Let $k_r(n,m)$ denote the minimum number of r-cliques in graphs with n vertices and m edges. Recently Razborov found $k_3(n,m)$ asymptotically. This talk presents a lower bound on $k_4(n,m)$ that approximates $k_4(n,m)$ with an error smaller than $n^4/\left(n^2-2m\right)$. The solution is based on a constraint minimization of certain multilinear forms. (Received September 16, 2008)

1046-05-1946 **Carolyn B Chun*** (cchun1@lsu.edu), Mathematics Department, Louisiana State University, Baton Rouge, LA 70803, **James Oxley** (oxley@math.lsu.edu), Mathematics Department, Louisiana State University, Baton Rouge, LA 70803, and **Dillon Mayhew**. *A Deletion-Contraction Theorem for Internally 4-connected Graphs.*

Tutte's Wheels Theorem asserts that, for a 3-connected graph G, there is an edge e in G such that the deletion or contraction of e from G is 3-connected and simple unless G is a wheel. In this talk, we present a similar result for internally 4-connected graphs. This theorem is a special case of a more general result for binary matroids. (Received September 16, 2008)

1046-05-2000 **Robert R Rubalcaba*** (r.rubalcaba@gmail.com), United States Department of Defense, 9800 Savage Road, Fort George G. Meade, MD 20755, and **Peter J Slater** (slater@math.uah.edu), Department of Mathematical Sciences, University of Alabama in Huntsville, 201 K Shelby Center, Huntsville, AL 35899. *Dominating Cartesian Products of Petersen and Grötzsch Graphs.*

Let $G\Box H$ denote the Cartesian product of G with H. Let P and C_k denote the Petersen Graph and cycle on k vertices, respectively. We bound the domination number of the Cartesian product of the Petersen Graph with cycles, $\gamma(P\Box C_k)$, by a simple function of k, for all $k \geq 3$. We conjecture that the domination number of $P\Box C_k$ meets this bound. We give a similar bound and conjecture for the Cartesian product of the Grötzsch graph with cycles. (Received September 16, 2008)

1046-05-2002 **Ameya A. Velingker*** (avelingk@fas.harvard.edu), 8 Currier Mail Center, 64 Linnaean St., Cambridge, MA 02138. *On an Exact Formula for the Coefficients of Han's Generating Function.*

Given a positive integer t and a partition λ, define $\mathcal{H}_t(\lambda)$ to be the multiset of hook lengths of λ that are divisble by t. For each nonnegative integer n, we consider the quantity $a_t(n) = a_t^{even}(n) - a_t^{odd}(n)$, where $a_t^{even}(n)$

(resp. $a_t^{odd}(n)$) is the number of partitions λ of n for which $\mathcal{H}_t(\lambda)$ has an even (resp. odd) number of elements. We prove an exact formula for $a_t^{even}(n) - a_t^{odd}(n)$ using a generating function for $a_t(n)$ discovered by Han in his generalization of the Nekrasov-Okounkov formula. Moreover, we obtain corollaries which describe the asymptotic behavior and sign of $a_t(n)$ for large n. (Received September 16, 2008)

1046-05-2019 **Charlie A. McIntosh*** (cmcintosh@wesleyan.edu), Dept. of Maths, Wesleyan University, Middletown, CT 06459. *Haar Graphs For Groups That Are Non-Cyclic.* Preliminary report.

We present results on Haar graphs (a.k.a. BiCayley graphs) for non-cyclic groups in the manner of those published by M. Hladnik, D. Marusic, and T. Pisanski. (Received September 16, 2008)

1046-05-2024 **Slawomir Solecki*** (ssolecki@math.uiuc.edu), Department of Mathematics, University of Illinois, Urbana, IL 61801. *A Ramsey theorem and dynamics.*

I will state a new finite Ramsey theorem that extends Proemel's theorem (which is a structural generalization of the Ramsey theorem for parameter sets). I will then explain possible consequences of this result to dynamics of the homeomorphism group of the pseudo-arc. (Received September 16, 2008)

1046-05-2084 **Richard Hammack*** (rhammack@vcu.edu), Dept. of Math. and Applied Math., Virginia Commonwealth University, Richmond, VA 23284. *Isomorphic components of direct products of bipartite graphs.*

The direct product of two connected bipartite graphs G and H has exactly two components. These components may or may not be isomorphic, depending on G and H. Ten years ago Jha, Klavžar and Zmazek proved that the components are isomorphic if one of G and H admits an automorphism that interchanges its partite sets, and they conjectured that the converse is true. We outline a proof of the converse. (Received September 17, 2008)

1046-05-2119 **John Y. Kim*** (kimjohn@mit.edu), MIT, Cambridge, MA. *The incidence game chromatic number*

The incidence game chromatic number was introduced to unify the ideas of the incidence coloring number and the game chromatic number. We determine the exact incidence game chromatic number of large paths and touch upon the clever strategy behind the proof. (Received September 19, 2008)

1046-05-2120 **Nathan K Pflueger*** (pflueger@stanford.edu), PO Box 12636, Stanford, CA 94309. *Binary rank and path invariance for reductions of signed graphs.*

We consider reductions of signed graphs, which are graph operations originally defined to formalize the assembly of genes in ciliates, a group of one-celled organisms. A signed graph is a graph whose vertices are each labeled either positive or negative, and a reduction is a process by which the graph is modified according to three operations, each of which reduces the number of vertices in the graph, until the empty graph is reached. We resolve several open problems regarding reductions of signed graphs by considering linear algebraic properties of the adjacency matrix of the graph over the finite field $\mathbb{F}_2$. In particular, signed graph reductions give a combinatorial interpretation to the rank of this matrix, sometimes called the binary rank of the graph, as well as to the inverse of this matrix in the case where it is invertible. Using this interpretation, we prove a conjecture of Harju et al. by demonstrating that the nullity of the adjacency matrix encodes an important invariant of the reduction process. We also prove a path invariance property of signed graph reduction, which can be used to improve the best-known computational complexity of a problem arising from reductions of signed graphs. (Received September 19, 2008)

06 ► *Order, lattices, ordered algebraic structures*

1046-06-121 **Ryan K Therkelsen*** (rtherke@ncsu.edu), Department of Mathematics, North Carolina State University, Box 8205, Raleigh, NC 27695-8205. *Order in the Conjugacy Poset of a Reductive Monoid.* Preliminary report.

Order in the Conjugacy Poset of a Reductive Monoid

Given a reductive monoid M with Renner monoid R and Gauss-Jordan elements $\mathcal{G}J$, there is associated a finite poset $(\tilde{R}, \leq)$ where $\tilde{R} = \mathcal{G}J/\sim$ and $\sim$ is conjugacy in R. $\tilde{R}$ can be decomposed into classes indexed by idempotents from the cross-section lattice of M. We briefly describe this decomposition and report on new results describing the order $\leq$, both within and between these classes. (Received July 29, 2008)

1046-06-662 **Andres Navas*** (anavas@usach.cl), Univ. de Santiago, Dp. Matematicas, Alameda 3363, Santiago, Chile, Santiago, Chile. *The Conrad property for left orderings on groups from a topological and a dynamical viewpoint.*

According to the work by P. Conrad, an ordering $\preceq$ on a group satisfies the condition C (or is Conradian) if for every $a \succ e$ and $b \succ e$ there exists $n \in \mathbb{N}$ such that $ab^n \succ b$. I plan to concentrate on two aspects of this property:
Topology: If the C-property holds then it holds for $n = 2$. This apparently innocuous remark implies that the space of Conradian orderings, endowed with a natural topology, is a compact space; moreover, it is homeomorphic to the Cantor set when it is nonempty and the group is non-solvable. Furthermore, it allows providing a new and short proof of the fact that a group admits a C-ordering if and only if it is locally indicable.
Dynamics: If the C-property holds and the group is countable, then an associated action by homeomorphisms of the real line has a special combinatorial property, namely there is no *resilient orbit* for the action. This notion has been studied by specialists on codimension-one foliations. Using techniques from this theory, this allows "visualizing" many properties which are equivalent to the Conradian one, although providing combinatorial proofs of the equivalence seems to be very hard. (Received September 09, 2008)

1046-06-774 **Elena Vinceková*** (vincekova@mat.savba.sk), Štefánikova, 49, Bratislava, 81473, and **Silvia Pulmannová**. *MV-pairs.*

Let us have a Boolean algebra B and its subgroup G of the automorphism group of B. Then an *MV-pair* is a BG-pair (B, G) satisfying two special conditions, recently introduced by Jenča (G. Jenča: *A representation theorem for MV-algebras.* Soft Computing. **11** (2007) 557–564). He proved, that if we consider $\sim_G$, an equivalence relation naturally associated with G, then for a given MV-pair (B, G), the quotient $B/\sim_G$ is an MV-algebra. Conversely, to every MV-algebra M there corresponds an MV-pair, which after factorization gives an MV-algebra isomorphic to M.

We study relations between congruences of B and congruences of $B/\sim_G$ which are induced by a G-invariant ideal I of B. We also bring some relations between ideals in MV-algebras and in the corresponding R-generated Boolean algebras (G. Grätzer: *General Lattice Theory.* Birkhäuser, Stuttgart, 1978; II.4). (Received September 16, 2008)

1046-06-942 **Adam J Clay*** (aclay@math.ubc.ca), Mathematics Department, University of British Columbia, Vancouver, BC V6T1Z2, Canada, and **Dale P O Rolfsen** (rolfsen@math.ubc.ca), Mathematics Department, University of British Columbia, Vancouver, BC V6T1Z2, Canada. *Limit points in the space of left orderings of a group.* Preliminary report.

If G is a group, $LO(G)$ denotes the set of all left-invariant strict total orderings of G, endowed with a natural topology defined by Sikora. The space $LO(G)$ is a compact, totally-disconnected Hausdorff space, which may or may not have isolated points (also known as finitely-determined orderings). For example, if G is free abelian of rank at least two, $LO(G)$ has no isolated points, whereas for the braid groups B_n there exist isolated orderings in $LO(B_n)$.

G acts on $LO(G)$ by conjugation, and we discuss the use of this action to determine which orderings are isolated, or possibly limit points of thier conjugates. (Received September 12, 2008)

1046-06-1071 **Homeira Pajoohesh*** (hpajoohesh@mec.cuny.edu). *A topology on lattice ordered groups.* Preliminary report.

Here we introduce a topology on an abelian lattice ordered goup G by using the absolute value of the difference of two elements as a metric valued in an abelian lattice ordered group and using the set of weak units of G as the set of radii. In the case of powers of the real numbers, this topology is the Euclidean topology. (Received September 14, 2008)

1046-06-1077 **Adam S. Sikora*** (asikora@buffalo.edu), 244 Math Bldg, SUNY Buffalo, Buffalo, NY 14260. *Topology of spaces of orderings of groups.* Preliminary report.

We survey topological properties of spaces of orderings of groups. We show that Conrad orderings of a large class of groups (including free and surface groups) form the Cantor space and, in particular, have no isolated orders. (Received September 14, 2008)

1046-06-1630 **Michael E Detlefsen*** (michael.detlefsen@sru.edu), Department Mathematics, Slippery Rock University, Slippery Rock, PA 16057. *Natural Poset Extensions of the Lattice of Integer Partitions.* Preliminary report.

Majorization partial order on Pn, the lattice of integer partitions, can be expressed as a tail sum. For each n, the mth power of the tail sum defines a poset Pn:m. For each n, the collection Pn:m is a finite chain of distinct combinatorial posets extending majorization and contracting the reverse lex chain order on the maximum poset Pn:M in this collection. Close predecessors of the maximal proper posets in this collection provide an new infinite collection of unranked combinatorial posets. We investigate a particular computability of meet and join in the posets Pn:m and relate the valid exponents on the tail to M. (Received September 16, 2008)

1046-06-1777 **Omid Ghayour*** (ghayour@scu.ac.ir), Department of Mathematics, Shahid Chamran University, Ahvaz, Iran, **Mehrdad Namdari** (namdari@ipm.ir), Department Of Mathematics, Ahvaz, Iran, and **M Motamedi** (motamedi_m@scu.ac.ir), Department of Mathematics, Ahvaz, Iran. *Some result in Lattices.*

It is well-known that every Artinian lattice is Loewy but not necessarily Noetherian. For an Artinian lattice we determine its deviation form being Noetherian in terms of its Loewy length. (Received September 16, 2008)

1046-06-2095 **Jennifer Anne Brown*** (jennifer.brown@csuci.edu). *Pseudotrees under the interval topology.* Preliminary report.

A *tree* is a partially ordered set $(T, \leq)$ such that the sets $T \downarrow t = \{r \in T : r \leq t\}$ are well-ordered. A *pseudo-tree* is a generalization of a tree: a partially ordered set $(T, \leq)$ such that the sets $T \downarrow t$ are only required to be linearly ordered. Let T be a pseudotree with a single root r, and define a topology τ on T by taking as a base all sets of the form $(s, t]$ (where $s, t \in T$ and $s \leq t$), together with the singleton set $\{r\}$. This interval topology (or "tree topology") has been well-studied in the case where T is in fact a tree. Permitting T to be merely a pseudotree means that many of the nice topological properties one finds in the case of the interval topology on trees no longer hold. For example, every tree is locally compact in the interval topology, but it is easy to construct a non-locally compact pseudotree. We examine to what extent some properties related to metrizability of trees with the interval topology hold in the case of pseudotrees. (Received September 17, 2008)

08 ► General algebraic systems

1046-08-1990 **Jason Worth Martin*** (martinjw@jmu.edu), MSC 1911 (Math Dept.), JMU, Harrisonburg, VA 22807. *ESSENCE: A Family of Cryptographic Hashing Algorithms.*

This paper describes the compression functions for a family of Merkle-Damgård based cryptographic hashing algorithms. The compression functions are based on a nonlinear, key-dependent permutation, E, of 256 or 512 bits built from 32 or 64 eight-bit nonlinear feedback shift-registers run in parallel with linear mixing between the shift-registers. The E permutation has been designed so that it can execute completely within the register file of modern 64-bit microprocessors and in constant time, thus increasing its resistance to side-channel attacks. We give a complete description of all criteria used for the constructions and provide differential and linear cryptanalysis. (Received September 16, 2008)

11 ► Number theory

1046-11-7 **Ken Ono*** (ono@math.wisc.edu), Department of Mathematics, University of Wisconsin, Madison, WI 53706. *Unearthing the visions of a master: The web of Ramanujan's mock theta functions.*

In his last letter to Hardy, dated January 20, 1920, Ramanujan defined 17 peculiar functions which he referred to *mock theta functions.* Although these mysterious functions have been investigated by many mathematicians, their most basic properties eluded discovery until 2002.

At the 1987 Ramanujan Centenary Conference at the University of Illinois, Freeman Dyson proclaimed:

"Mock theta-functions give us tantalizing hints of a grand synthesis still to be discovered. Somehow it should be possible to build them into a coherent group- theoretical structure... This remains a challenge for the future. My dream is that I will live to see the day when our young physicists, struggling to bring the predictions of superstring theory into correspondence with the facts of nature, will be led to enlarge their analytic machinery to include not only theta-functions but mock theta-functions."

Here we describe the solution to Dyson's "challenge for the future", the theory of harmonic Maass forms. These automorphic forms have quickly found many applications: Complex multiplication in Number Theory, Donaldson invariants, Gross-Zagier formulae, Partitions, to name a few. We shall give an indication of some of these applications. (Received September 02, 2008)

1046-11-28 **Lloyd J Kilford*** (l.kilford@gmail.com), Department of Mathematics, University Walk, Bristol, BS8 1TW, England. *Explicit computations of Hecke operators on automorphic forms.*

We will give a brief introduction to classical and overconvergent automorphic forms, and present the results of explicit computations relating automorphic forms and elliptic modular forms of weight 1 (using a form of the Jacquet-Langlands correspondence). This is joint work with Kevin Buzzard. (Received June 13, 2008)

1046-11-42 **Byungchul Cha*** (cha@muhlenberg.edu), 2400 Chew Street, Allentown, PA 18104. *Chebyshev's bias in function fields.*

We study a function field counterpart of *Chebyshev's bias*, a phenomenon observed first by Chebyshev in 1853 that there tend to be more prime numbers that are congruent to 3 modulo 4 than those congruent to 1. We show the similarities and differences between our function field case and the work of Rubinstein and Sarnak in 1994 for the case of the number field. (Received June 30, 2008)

1046-11-49 **Wendell Ressler*** (wendell.ressler@fandm.edu), Department of Mathematics, PO Box 3003, Lancaster, PA 17604-3003. *A Hecke Correspondence Theorem for Automorphic Integrals with Symmetric Rational Period Functions on the Hecke Groups.*

Marvin Knopp developed the theory of automorphic integrals, which generalize automorphic forms; each automorphic integral has an additional period function in its automorphic relation. The period functions satisfy relations that arise from the underlying group relations. Knopp showed that entire automorphic integrals with rational period functions satisfy a Hecke correspondence theorem, provided the rational period functions have poles only at 0 or ∞. For other automorphic integrals each corresponding Dirichlet series has a functional equation with a remainder term that arises from the nonzero poles of the rational period function.

In this paper we prove a Hecke correspondence theorem for a class of automorphic integrals with rational period functions on the Hecke groups. We restrict our attention to automorphic integrals of weight that is twice an odd integer and to rational period functions that satisfy a symmetry property we call "Hecke-symmetry." We explicate the relationship between the structure of the rational period functions and the corresponding remainder terms. Each remainder term satisfies two relations (the second of which is new in this paper) corresponding to the two relations for the rational period function. (Received July 09, 2008)

1046-11-60 **Ana Berrizbeitia*** (bubyta28@mail.utexas.edu), Department of Mathematics, University of Texas at Austin, 1 University Station, C1200, Austin, TX, **Alexander Moll** (alexmollmail@gmail.com), Mathematics Department, Columbia University, New York City, NY , and **Laine Noble** (lnoble@tulane.edu), Department of Mathematics, Tulane University, New Orleans, LA 70118. *p-adic properties of Stirling numbers.*

The 2-adic properties for Stirling numbers of the second kind, for k fixed, were recently analyzed by T. Amdeberhan et al. We generalize their conjectures for p and odd prime. Using the periodicity of S(n,k) modulo powers of p, we have established these conjectures for special cases of p and k. The case k<p is described in detail. (Received July 16, 2008)

1046-11-115 **Jeffrey Hatley*** (hatley2@tcnj.edu), 10 Cragmoor Drive, Shamong, NJ 08088, and **Amanda Hittson** (amanda.hittson@gmail.com), 1737 Bannister Rd., Anchorage, AK 99508. *Numerical Evidence on the Uniform Distribution of Power Residues for Elliptic Curves.*

Let E be an elliptic curve over the rational numbers. For each rational prime p, let N_p denote the number of points on E reduced modulo p. We computationally investigate the distribution of primes, p, such that N_p is a quadratic residue modulo p. The primes appear to satisfy a Dirichlet-like uniform distribution for elliptic curves without complex multiplication. This investigation is motivated by a similar conjecture, due to Weston, about the distribution of primes having a_p a quadratic residue. (Received July 25, 2008)

1046-11-127 **James G Mc Laughlin*** (jmclaughl@wcupa.edu), 25 University Avenue, West Chester, PA 19383. *Some new Families of Tasoevian- and Hurwitzian Continued Fractions.*

We derive closed-form expressions for several new classes of Hurwitzian- and Tasoevian continued fractions, including

$$[0;\overline{p-1,1,u(a+2nb)-1,p-1,1,v(a+(2n+1)b)-1}\,]_{n=0}^{\infty},$$

$[0;\overline{c+dm^n}]_{n=1}^{\infty}$ and $[0;\overline{eu^n,fv^n}]_{n=1}^{\infty}$. One of the constructions used to produce some of these continued fractions can be iterated to produce both Hurwitzian- and Tasoevian continued fractions of arbitrary long quasi-period, with arbitrarily many free parameters and whose limits can be determined as ratios of certain infinite series.

We also derive expressions for arbitrarily long *finite* continued fractions whose partial quotients lie in arithmetic progressions. (Received July 31, 2008)

1046-11-142 **Eugen Andrei Ghenciu*** (ffeag@uaf.edu), P.O. Box 750232, Fairbanks, AK 99775.
Polynomial Continued Fractions and Iterated Function Systems. Preliminary report.

We investigate the connections between polynomial continued fractions and iterated function systems. For many continued fraction expansions (cf-expansions), one can associate a conformal iterated function system (CIFS). Depending on the particular form of the cf –expansion, the CIFS may or may not have overlaps. We ask several questions related to the geometric properties of the associated limit set and we look at some number theoretic applications. (Received August 06, 2008)

1046-11-216 **Paul Fili**, Department of Mathematics, University of Texas at Austin, 1 University Station C1200, Austin, TX 78712, and **Charles L Samuels***, Max-Planck-Institüt für Mathematik, Vivatsgasse 7, 53111 Bonn, Germany. *The non-Archimedean metric Mahler measure.*

Recently, Dubickas and Smyth constructed and examined the metric Mahler measure on the multiplicative group of algebraic numbers. We give a non-Archimedean version of the metric Mahler measure, denoted μ_∞, and prove that $\mu_\infty(\alpha) = 1$ if and only if α is a root of unity. In the process, we resolve an interesting special case of the famous Lehmer problem. We further show that $\mu_\infty(\alpha^r) = \mu_\infty(\alpha)$ for all non-zero rational r and we demonstrate how to compute $\mu_\infty(\alpha)$ when α is a surd. (Received August 20, 2008)

1046-11-252 **Alex V Kontorovich*** (alexk@math.brown.edu), Department of Mathematics, Brown University, 151 Thayer Street, Providence, RI 02912, and **Hee Oh** (heeoh@math.brown.edu), Department of Mathematics, Brown University, 151 Thayer Street, Providence, RI 02912.
Orbital Counting for Thin Groups and the Affine Linear Sieve.

We will discuss recent progress on the Affine Linear Sieve, which finds integers with a bounded number of prime factors inside a set generated by a non-linear group action. The methods involve the Patterson-Sullivan results on Hausdorff dimensions of limit sets, expander graphs, and spectral methods for infinite-volume hyperbolic surfaces. (Received August 23, 2008)

1046-11-258 **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. *Ray class groups.*

This talk concerns some computations involving ray class groups. First I will give a structure of ray class groups for some prime cyclotomic number fields. As an application, a description of tamely ramified meta-abelian Galois groups will be given. Then I will present some results about nilpotent Galois extensions over quadratic fields $\mathbb{Q}(\sqrt{d})$ ramified only at one prime by computing the ray class number of $\mathbb{Q}(\sqrt{d})$. (Received August 24, 2008)

1046-11-265 **Nathan C Ryan***, Department of Mathematics, Lewisburg, PA 17837, and **Lauren Grainer**, **Kevin McGoldrick**, **Sharon Anne Garthwaite**, **Cris Poor**, **David W Farmer**, **David S Yuen** and **Ralf Schmidt**. *Experiments with Siegel Modular Forms.*

There are a number of conjectures (and theorems) that hold for modular forms on $\mathrm{SL}(2, \mathbb{Z})$ whose description is the result of large amounts of computation. In this talk we will discuss recent computational work that has been done for analogous conjectures for modular forms on $\mathrm{Sp}(2n, \mathbb{Z})$. The conjectures which have been generalized include an analogue of Maeda's conjecture, the Sato-Tate conjecture, and the Riemann Hypothesis for L-functions attached to modular forms. Additionally, we will make note of two liftings of classical modular forms to Siegel modular forms on $Sp(8, \mathbb{Z})$. (Received August 24, 2008)

1046-11-266 **Craig Citro**, **Alexandru Ghitza** and **Nathan C. Ryan***, Department of Mathematics, Bucknell University, Lewisburg, PA 17837, and **Nils-Peter Skoruppa**. *Siegel modular forms in Sage.*

In this talk I give an overview of what code has been written to handle Siegel modular forms in Sage. Additionally, I will describe some computational and theoretical results that have resulted from this code. (Received August 24, 2008)

1046-11-283 **Laura L. Hall-Seelig***, Dept. of Mathematics and Statistics, Lederle Graduate Research Tower, University of Massachusetts, Amherst, MA 01003-9305. *New Lower Bounds for the Ihara Function $A(q)$.*

The study of curves over finite fields lies at the intersection of number theory and algebraic geometry. The Ihara function demonstrates an asymptotic relationship between the number of points on a curve defined over a finite field and its genus. The exact behavior of this function is not known; however, many bounds for its values have been computed. Using the computer algebra system MAGMA, we have been able to improve some known explicit lower bounds. (Received August 25, 2008)

1046-11-288 **Lisa A Berger*** (lbrgr@math.sunysb.edu), Mathematics Departement, Stony Brook University, Stony Brook, NY 11790-3651. *Elliptic curves of large rank in towers of function fields.*

In this talk we will discuss a recent construction of a one-parameter family of elliptic curves over $\mathbb{F}_q(t^{1/d})$ whose members obtain arbitrarily large rank as $d \to \infty$. We'll begin with some background material on elliptic curves and their ranks, discuss the interesting geometry in the proof, and see some examples. The talk is accessible to a general matheamtical audience. (Received August 25, 2008)

1046-11-308 **Penny C Ridgdill*** (ridgdill@math.umass.edu), 83 Crescent St, Northampton, MA 01060. *On the Frequency of Anomalous Primes for Elliptic Curves.* Preliminary report.

For an elliptic curve E, a prime is called anomalous for E if $a_p = 1$, where $a_p = p + 1 - \#E(F_p)$. We would like to know how often we can avoid such primes. We know that for non-cm curves this happens finitely often due to a result of Serre's. By looking at the images of the (mod p) Galois representation of the curve, and looking at when those images are trace 1 free, we are able to classify when we are able to avoid $a_p = 1$. (Received August 25, 2008)

1046-11-311 **Adriana Julia Salerno*** (asalerno@math.utexas.edu), 3202 Grooms St Apt G, Austin, TX 78705. *Rational Points and Hypergeometric Functions.*

We study the number of $\mathbb{F}_q$-rational points $N(\lambda)$ of a hypersurface in $P^{n-1}_{\mathbb{F}_q}$ defined by the equation

$$x_1^d + \cdots + x_n^d = d\lambda x_1^{h_1} \cdots x_n^{h_n}$$

where $d|q-1$, $h_1 + \cdots + h_n = d$ and $g.c.d.(d, h_1, \ldots, h_n) = 1$. We find that $N(\lambda)$ is the finite field version of a hypergeometric function, and we explore the possibility that hypergeometric functions may always appear when counting points. (Received September 11, 2008)

1046-11-316 **Kristen J Campbell*** (campbell@math.niu.edu), Department of Mathematical Sciences, Northern Illinois University, Dekalb, IL 60115. *Characterizing Limits of Analytic Continued Fractions.* Preliminary report.

Historically, investigation of convergence of analytic continued fractions has primarily separated them into two categories: those that converge and those that do not. However, recent work by Bowman has focused on those that diverge, but in a predictable manner. Employing his notion of the sequential closure of a sequence, we obtain precise for limit k-periodic continued fractions as well as q-continued fractions. (Received August 25, 2008)

1046-11-349 **David Hannasch*** (davidh@egr.unlv.edu), **Rene Ardila**, **Audra Kosh**, **Hanah McCarthy**, **Ryan Rosenbaum**, **Donald Adams** and **Vadim Ponomarenko**. *Matrix Number Theory: Factorization in Integral Matrix Semigroups.* Preliminary report.

Factorization theory is a prominent field of mathematics; however, most previous research in this area lies in the commutative case. Noncommutative factorization theory is a relatively new topic of interest. This talk examines the factorization properties of noncommutative atomic semigroups of matrices, including results on the minimum and maximum length of atomic factorizations, the elasticity and the delta set of the semigroups. (Received August 27, 2008)

1046-11-361 **Joseph H Silverman*** (jhs@math.brown.edu), Mathematics Department - Box 1917, Brown University, 151 Thayer Street, Providence, RI 02912. *On the greatest common divisor of $a^n - 1$ and $b^n - 1$.* Preliminary report.

A conjecture of Rudnick and Ailon asserts that for multiplicatively independent integers $a > 1$ and $b > 1$, there are infinitely many exponents $n \geq 1$ such that $\gcd(a^n - 1, b^n - 1) = \gcd(a - 1, b - 1)$. We present experimental evidence and a heuristic argument for the statement that the number of primes $p < X$ such that $\gcd(a^p - 1, b^p - 1) = \gcd(a-1, b-1)$ is equal to $\pi(X)(1 + O(1/\log X))$. We will also discuss generalized versions of the Rudnick–Ailon conjecture for elliptic curves and other algebraic groups. (Received August 27, 2008)

1046-11-391 **Chris A. Kurth** and **Ling Long*** (linglong@iastate.edu), 396 Carver Hall, Ames, IA 50011. *The unbounded denominator property of noncongruence modular forms.*

In this talk we only consider integral weight modular forms which are holomorphic on the upper half plane and have algebraic coefficients. It is known that if such a modular form is invariant under a congruence subgroup then its Fourier coefficients have bounded denominators. The converse is an open question and it has many potential applications. A noncongruence subgroup is said to satisfy the unbounded denominator condition if every genuine modular form for the group (with the above properties) has unbounded denominators. We will show that the unbounded denominator property is satisfied by two general classes of noncongruence subgroups. (Received August 29, 2008)

1046-11-398 **Maria J Monks*** (monks@mit.edu), 290 Massachusetts Avenue, Cambridge, MA 02139. *Number theoretic properties of generating functions related to Dyson's rank for partitions into distinct parts.*

Let $Q(n)$ denote the number of partitions of n into distinct parts. We show that Dyson's rank provides a combinatorial interpretation of the well-known fact that $Q(n)$ is almost always divisible by 4. This interpretation gives rise to a new false theta function identity that reveals surprising analytic properties of one of Ramanujan's mock theta functions, which in turn gives generating functions for values of certain Dirichlet L-functions at non-positive integers. (Received August 31, 2008)

1046-11-418 **Keith R. Matthews** and **John P. Robertson*** (JPR2718@AOL.COM), 600 Gardenia Ter, Delray Beach, FL 33444, and **Jim White**. *Nearest Square Continued Fractions, and Related Results.*

We present

(a) A theorem that for any quadratic irrational, the lengths of the periods of the nearest square continued fraction (NSCF) and the nearest integer continued fraction (NICF) are the same,

(b) Three criteria for recognizing the midpoint of the NSCF of $\sqrt{D}$ without computing the whole period, and

(c) A simple characterization of quadratic irrationals that have purely periodic NICFs.

The NSCF is derived from the cyclic method of Bhaskara as developed by A. A. Krishnaswami Ayyangar.

To prove the equality of the period lengths we study the singularization process whereby segments of the regular continued fraction with partial quotients of 1 are transformed into shorter segments in the NSCF and NICF. We also look at how well the convergents approximate the quadratic irrational to study some of the more subtle aspects of the singularization process for the NSCF. (Received September 01, 2008)

1046-11-423 **Olav K Richter*** (richter@unt.edu), University of North Texas, Department of Mathematics, 1155 Union Circle #311430, Denton, TX 76203-5017, and **Kathrin Bringmann** and **Charles H Conley**. *Jacobi forms over complex quadratic fields via the cubic Casimir operators.* Preliminary report.

I will report on a new approach to Jacobi forms over complex quadratic fields, which is recent joint work with K. Bringmann and C. Conley.

We prove that the center of the algebra of differential operators invariant under the action of the Jacobi group over a complex quadratic field is generated by two cubic Casimir operators, which we compute explicitly. In the spirit of Borel, we consider Jacobi forms over complex quadratic fields that are also eigenfunctions of these Casimir operators, a new approach in the complex case. Theta functions and Eisenstein series provide standard examples. In addition, we introduce an analog of Kohnen's plus space for half-integral weight modular forms over $K = Q(i)$, and provide a lift from it to the space of Jacobi forms over $K = Q(i)$. (Received September 02, 2008)

1046-11-453 **Brian C. Dietel*** (dietelb@onid.orst.edu), Oregon State University, Department of Mathematics, 368 Kidder Hall, Corvallis, OR 97331. *Mahler's order functions and p-adic algebraic approximation.*

If P is a polynomial of degree d define $\Lambda(P)$ to be the product of 2^d with the sum of the absolute value of the coefficients of P. In a 1971 paper Kurt Mahler defined the "order function" of each complex number α by $O(u|\alpha) = \sup \log |\frac{1}{P(\alpha)}|$ where the supremum is taken over all integer polynomials P satisfying $\Lambda(P) \leq u$ and $P(\alpha) \neq 0$. By placing a partial order on the order functions Mahler induced a classification of the complex numbers. We will consider the properties of order functions when α is a p-adic number. Many of the results previously obtained in the real case still hold for the p-adics. However, the unique properties of the p-adic numbers result in several exceptions. (Received September 03, 2008)

1046-11-501 **Sander Zwegers*** (sander.zwegers@ucd.ie), School of Mathematical Sciences, University College Dublin, Belfield, Dublin 4, Ireland. *Indefinite Theta Functions.*

One of the very few known general constructions of holomorphic modular forms is via theta series: if Q is a positive definite integer-valued quadratic form on a lattice L of rank n, then the associated theta function is a modular form of weight $n/2$. We wish to generalize this result to the case when Q is allowed to be indefinite. For quadratic forms of type $(n-1,1)$, we can define suitable theta functions, which are, in general mock modular forms. In certain special cases we get holomorphic modular forms. In this talk we'll describe general results in both directions. We'll also consider quadratic forms of more general type. This, however, is work in progress. (Received September 05, 2008)

1046-11-573 **Joshua Harrington*** (jh3293@ship.edu), Department of Mathematics, Shippensburg University, Shippensburg, PA 17257, and **Lenny Jones** (lkjone@ship.edu), Department of Mathematics, Shippensburg University, Shippensburg, PA 17257. *On the Iteration of a Function Related to Euler's ϕ-Function.* Preliminary report.

A unit x in a commutative ring R with identity is called *exceptional* if $1-x$ is also a unit in R. For any integer $n \geq 2$, define $\phi_e(n)$ to be the number of exceptional units in the ring of integers modulo n. Following work of Shapiro, Mills, Catlin and Noe on iterations of Euler's ϕ-function, we develop analogous results on iterations of the function ϕ_e, when restricted to a particular subset of the positive integers. (Received September 08, 2008)

1046-11-579 **Donald Mills*** (dmills@wittenberg.edu), Department of Mathematics, Wittenberg University, Springfield, OH 45501-0720. *Polynomials Built Using Lucas Sequence Pairs.* Preliminary report.

Recall that if p, $q \in \mathbb{Z}$ are chosen so that $d = p^2 - 4q > 0$, then the zeroes $a = (p+\sqrt{d})/2$ and $b = (p-\sqrt{d})/2$ of the polynomial $l(x) = x^2 - px + q$ may be used to construct the real-valued sequences $\{u_n\}$ and $\{v_n\}$, n natural, with $u_n = (a^n - b^n)/(a-b)$ and $v_n = a^n + b^n$ for each n. Said sequences are called *Lucas sequences* (LS for short). The speaker shall call these sequences the LS-u and LS-v sequences, respectively.

Now define the following polynomial sequence. Set $L_{u,0}(x) = u_1$ and $L_{u,m}(x) = xL_{u,m-1}(x) + u_{m+1}$ for $m \geq 1$, with $L_{u,m}(x) = \sum_{k=0}^{m} u_{k+1}x^{m-k}$. Call $L_{u,m}(x)$ the LS-u polynomial of order m.

The speaker (with D. Garth and P. Mitchell) has answered several questions regarding the LS-u polynomial sequence formed by the Fibonacci sequence. While their queries regarding zeroes of said polynomials were answered independent of consideration of the LS-v sequence, answers to questions pertaining to Mahler measures of related polynomials relied extensively upon the intimate relationship between said sequences.

This talk focuses upon the speaker's initial investigations into answering questions regarding zeroes for a general LS-u polynomial sequence. (Received September 08, 2008)

1046-11-598 **D Bowman** (bowman@math.niu.edu), Northern Illinois University, Department of Mathematical Sciences, Watson Hall 320, Dekalb, IL 60115-2888, and **K J Campbell*** (campbell@math.niu.edu), Northern Illinois University, Department of Mathematical Sciences, Watson Hall 320, Dekalb, IL 60115-2888. *Classifying Sequential Closures of q-continued Fractions.* Preliminary report.

Historically, investigation of convergence of analytic continued fractions has primarily separated them into two categories: those that converge and those that do not. However, recent work by Bowman and McLaughlin has focused on those that diverge, but in a predictable manner. Employing their notion of the sequential closure of a sequence, we give a classification theorem for the sequential closures for limit 1-periodic q-continued fractions, that is, continued fractions of the form

$$\frac{a_0 + \cdots + a_l q^l}{b_0 + \cdots + b_k q^k +} \quad \frac{a_0 + \cdots + a_l q^{2l}}{b_0 + \cdots + b_k q^{2k} +} \quad \frac{a_0 + \cdots + a_l q^{3l}}{b_0 + \cdots + b_k q^{3k} +} \quad \cdots$$

where q, a_i, b_i are complex numbers, $|q| \neq 1$, and $l, k > 0$. (Received September 08, 2008)

1046-11-624 **Patrick X Rault*** (rault@geneseo.edu), Department of Mathematics, 326C South Hall, State University of New York, Geneseo, NY 14454. *On uniform bounds for rational points on rational curves and thin sets.* Preliminary report.

We use rational parametrizations and Fourier techniques to make progress on an open question about counting rational points on plane curves. Heath-Brown proved that for any $\epsilon > 0$ the number of rational points of height at most B on a degree d plane curve is $O_{\epsilon,d}(B^{2/d+\epsilon})$ (the implied constant depends on ϵ and d). It is known that Heath-Brown's theorem is sharp apart from the ϵ, but in certain cases the bound has been improved to $\epsilon = 0$. The open question is whether or not the bound with $\epsilon = 0$ holds in general. We shed additional light on this open problem by giving, in certain cases, an improved upper bound which is inversely proportional to a positive power of the resultant of the curve. (Received September 09, 2008)

1046-11-645 **P. Charters*** (pcharter@math.utexas.edu), Department of Mathematics, 1 University Station, C1200, Austin, TX 78751. *Generalizing Binary Quadratic Residue Codes.*

The quadratic residue codes are a family of codes that have historically been of interest due to their strong properties - they have transmission rate close to $\frac{1}{2}$, and a square root lower bound on their minimal distance. In this talk we will define a new family of codes, which we will call q-residue codes, that will generalize the quadratic residue codes using higher powered prime residues over fields of the corresponding order. Some of the important properties of these new codes will also be discussed. (Received September 09, 2008)

1046-11-707 **John Cullinan*** (cullinan@bard.edu), Department of Mathematics, Bard College, Annandale-On-Hudson, NY 12504, and **Farshid Hajir**. *Orthogonal polynomials and ranks of abelian varieties.* Preliminary report.

We present work in progress on the ranks of Jacobians of the algebraic curves defined by the Generalized Laguerre and Generalized Jacobi polynomials. (Received September 10, 2008)

1046-11-725 **Thomas J. Wright*** (wright@math.jhu.edu), Department of Mathematcs, Johns Hopkins University, 3400 North Charles St., Baltimore, MD 21218. *Convergence of Singular Series for a Pair of Quadratic Forms.*

Examining the system of Diophantine equations

$$\begin{cases} f_1(x) = x_1^2 + ...x_n^2 = \nu_1, \\ f_2(x) = \lambda_1 x_1^2 + ...\lambda_n x_n^2 = \nu_2, \end{cases}$$

with $\lambda_i \neq \lambda_j$ and $\nu_i, \lambda_i \in \mathbb{Z}$, we develop what is known as the singular series $S(\nu)$, a quantity which is understood to approximate the number of solutions for this pair of equations as the ν_i's become larger. We show that this singular series $S(\nu)$ converges if $n \geq 6$. (Received September 10, 2008)

1046-11-750 **Mary E. Flahive*** (flahive@math.oregonstate.edu) and **Richard T. Bumby** (bumby@math.rutgers.edu). *Applying the divided cell algorithm.* Preliminary report.

Originally designed by B. N. Delone [Izv. Akad. Nauk SSSR 11 (1947), 505-538], the divided cell algorithm is an inhomogeneous version of the regular simple continued fraction algorithm. It was developed by Delone to calculate the inhomogeneous minimum of binary quadratic forms, and its development was continued by E. S. Barnes and H. P. F. Swinnerton-Dyer [Acta Math. 92 (1954), 199-234] and Jane Pitman [Acta Arith. 5 (1958), 81-116]. Advances in computing and the modernization of linear algebra have allowed us to simplify the algorithm. In this talk we show how the updated algorithm can be used to recast and simplify some of Davenport's work [Quart. J. Math 1 (1950), 54-62; Nederl. Akad. Wetensch. 50 (1947), 484-491, 741-749, 909-917]. (Received September 10, 2008)

1046-11-761 **Daniel C Scheinerman*** (daniel_scheinerman@brown.edu), 69 Brown Street, Brown University Box 2088, Providence, RI 02912, and **Steven J Miller**. *Explicit constructions of infinite families of MSTD sets.*

We give explicit, infinite families of MSTD (more sums than differences) sets. There are enough of these sets to prove that there exists a constant C such that at least C/r^4 of the 2^r subsets of $\{1, \ldots, r\}$ are MSTD sets; thus our family is significantly denser than previous constructions (whose densities are typically at most $f(r)/2^{r/2}$ for some polynomial $f(r)$). (Received September 11, 2008)

1046-11-762 **Yi Sun*** (yisun@fas.harvard.edu), 206 Cabot Mail Center, 60 Linnaean St., Cambridge, MA 02138. *On the cyclotomic Littlewood polynomials.*

We study cyclotomic polynomials of odd degree with coefficients in the set $\{-1, +1\}$. In 1999, P. Borwein and K. K. Choi conjectured that $P(x)$ is a cyclotomic polynomial of degree $N-1$ with coefficients in the set $\{-1, +1\}$ if and only if

$$P(x) = \pm\Phi_{p_1}(\pm x)\Phi_{p_2}(\pm x^{p_1}) \cdots \Phi_{p_k}(\pm x^{p_1 p_2 \cdots p_{k-1}})$$

for some (not necessarily distinct) primes $p_1, p_2, \ldots, p_k$ such that $N = p_1 p_2 \cdots p_k$. Here $\Phi_p(x) = 1+x+\cdots+x^{p-1}$ is the p^{th} irreducible cyclotomic polynomial. They proved this conjecture for polynomials of even degree. In 2008, S. Akhtari and K. K. Choi proved the conjecture for degree $2^a p^b - 1$ with p an odd prime and for $P(x)$ separable. By using Newton's identities to compare the power sums of $P(x)$ with a specific class of power sums, we prove the conjecture for degree $2^t pq - 1$ with $p, q > 2^{t+1}$ odd primes. In particular, this resolves the case of degree $2pq - 1$. (Received September 11, 2008)

1046-11-777 **Soon-Yi Kang*** (sykang@kias.re.kr), ASARC, Department of Mathematics, KAIST, Daejeon, 305-701, South Korea. *Mock Jacobi forms and the ${}_1\psi_1$ summation formula.*

We show that some q-series such as universal mock theta functions are linear sums of theta quotient and mock Jacobi forms of weight 1/2, which become holomorphic parts of real analytic modular forms when they are multiplied by suitable powers of q. And we prove that certain linear sums of q-series that arise from Ramanujan's ${}_1\psi_1$ summation formula are weakly holomorphic modular forms of weight 1/2 due to annihilation of mock Jacobi forms or completion by mock Jacobi forms. As an application, we obtain a relation between the rank and crank of a partition. (Received September 11, 2008)

1046-11-781 **Matthew P Young*** (myoung@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77845, and **K Soundararajan**. *The second moment of quadratic twists of a modular L-function.*

The family of quadratic twists of a modular form (or the corresponding family of L-functions) has been intensively studied by many researchers. One particularly strong motivation is for understanding ranks of quadratic twists of elliptic curves. I will discuss recent work (joint with K. Soundararajan) where we obtain an asymptotic formula for the second moment of central values of this family of L-functions, conditionally on GRH. Unconditionally, we show that the second moment is no smaller than the conditional asymptotic. (Received September 11, 2008)

1046-11-804 **Riad Masri*** (masri@math.wisc.edu), Department of Mathematics, University of Wisconsin, Madison, WI 53706, and **Amanda Folsom**. *Non-harmonic weak Maass forms and arithmetic geometry.* Preliminary report.

The theory of harmonic weak Maass forms, developed by Bruinier, Ono, Yang, and their collaborators, has been revealed to have profound connections with arithmetic geometry. Less attention has been paid to non-harmonic weak Maass forms. In this talk, I will explain the connection between a certain non-harmonic weak Maass form, arithmetic geometry, and a classical problem in number theory. This is joint work with Amanda Folsom. (Received September 11, 2008)

1046-11-811 **Kelley Harris*** (harris.kelley@gmail.com), 213 Quincy Mail Center, 58 Plympton St, Cambridge, MA 02138. *On Integers n that Divide $\phi(n) + \sigma(n)$.*

The expressions $\phi(n) + \sigma(n) - 3n$ and $\phi(n) + \sigma(n) - 4n$ are unusual among linear combinations of arithmetic functions in that they each vanish on a nonempty set of composite numbers. In 1966, Nicol proved that the set $\mathcal{A} = \{n \mid (\phi(n) + \sigma(n))/n \in \mathbb{N}_{\geq 3}\}$ contains $2^a \cdot 3 \cdot (2^{a-2} \cdot 7 - 1)$ if and only if $2^{a-2} \cdot 7 - 1$ is prime and conjectured that $\mathcal{A}$ contains no odd integers. In this paper, we let $\mathcal{A}_K$ denote the set of $n \in \mathcal{A}$ with exactly K prime factors and present an algorithm that decides whether Nicol's conjecture holds for a given $\mathcal{A}_K$. We verify Nicol's conjecture for numbers with fewer than seven prime factors, and completely classify the elements of $\mathcal{A}$ that have fewer than five prime factors. In addition, we prove that every $\mathcal{A}_K$ is contained in a finite union of sequences that each converge with respect to some p-adic norm, and that the elements of $\mathcal{A}_4$ and $\mathcal{A}_5$ are contained in a 2-adically convergent sequence. (Received September 11, 2008)

1046-11-832 **Richard T Bumby*** (bumby@math.rutgers.edu), Department of Mathematics, Hill Center, Busch Campus, 110 Frelinghuysen Rd, Piscataway, NJ 08854-8019, and **Mary E Flahive**. *Quadratics, continued fractions and divided cells.* Preliminary report.

The usual algorithm for computing ideal classes and units in orders of quadratic number fields is identical in structure to the ordinary continued fraction, although it is usually described differently. In addition there is a formal process connecting the divided cell algorithm used in inhomogeneous problems with the ordinary continued fraction. This allows the natural methods of one of these settings to be applied in the other two. We describe some explicit computations using the rules of one of these settings, but applied to natural questions of another. (Received September 11, 2008)

1046-11-858 **Thomas Garrity*** (tgarrity@williams.edu), Dept. of Mathematics and Statistics, Williams College, Williamstown, MA 01267. *On a Thermodynamic Classification for Real Numbers.* Preliminary report.

A new classification scheme for real numbers is proposed, motivated by ideas from statistical mechanics in general and work of Knauf and of Fiala and Kleban in particular. For each real number we associate a partition function and ask about the nature of the corresponding free energy. We will see that the diophantine properties of the initial number's continued fraction expansion determines critical properties for the corresponding free energy function. (Received September 12, 2008)

1046-11-873 **John H. Jaroma*** (john.jaroma@avemaria.edu), Department of Mathematics & Physics, Ave Maria University, Ave Maria, FL 34142. *On Prime Factors of $A^n \pm 1$.* Preliminary report.

A short time ago, Ishikawa, Ishida, and Yukimoto demonstrated: *The prime factors of $A^m - 1$ and $A^n - 1$ coincide if and only if $m = 1$, $n = 2$, and $A = 2^l - 1$; The prime factors of $A^m - 1$ are a subset of those of $A^n - 1$ if and only if $m \mid n$, or $m = 2$ and $A = 2^l - 1$.* We shall show that both parts of this theorem follow nicely using Zgismondy's Theorem. Also to be presented is an analogous result for $A^n + 1$. (Received September 12, 2008)

1046-11-878 **Jenny G. Fuselier*** (jenny.fuselier@usma.edu). *Traces of Hecke operators in level 1 and Gaussian hypergeometric functions.*

In this talk, we explore relationships between traces of Hecke operators in level 1, counting points on a family of elliptic curves over $\mathbb{F}_p$, and values of a ${}_2F_1$ hypergeometric function over $\mathbb{F}_p$. In particular, for primes p congruent to 1 mod 12, we present a formula for Ramanujan's tau function at p in terms of 10^{th} powers of a hypergeometric function. We also present a recursive formula for the traces of Hecke operators in level 1 in terms of the same Gaussian hypergeometric function. (Received September 12, 2008)

1046-11-974 **Ken McMurdy*** (kmcmurdy@ramapo.edu), Department of Mathematics (TAS), Ramapo College of New Jersey, 505 Ramapo Valley Rd., Mahwah, NJ 07430. *Stable Reduction of $X_0(625)$, with Implications.*

In this talk, we will show how to explicitly compute the stable reduction of the modular curve, $X_0(625)$, at the prime $p = 5$. This example supports a slight variation of an earlier conjecture regarding $X_0(p^4)$ in the general case, which was based on $X_0(81)$. So we will conclude the talk with a statement of the revised conjecture, as well as a brief status report on its proof. (Received September 13, 2008)

1046-11-980 **Helen G. Grundman*** (grundman@brynmawr.edu), Department of Mathematics, Bryn Mawr College, 101 N. Merion Ave., Bryn Mawr, PA 19010. *Happy Numbers and Semihappy Numbers.*

Let $\mathbf{e} = (e_0, e_1, \dots)$ be a sequence with $e_0 = 2$ and $e_i \in \{1, 2\}$ for $i > 0$. Let $S_{\mathbf{e}} : \mathbf{Z}^+ \to \mathbf{Z}^+$ be defined by

$$S_{\mathbf{e}}\left(\sum_{i=0}^{n} a_i 10^i\right) = \sum_{i=0}^{n} a_i^{e_i}.$$

An $\mathbf{e}$-*semihappy number* is a positive integer a such that for some $k \in \mathbf{Z}^+$,

$$S_{\mathbf{e}}^k(a) = 1.$$

Recall that a *happy number* is the special case of an $\mathbf{e}$-semihappy number with $\mathbf{e} = (2, 2, 2, \dots)$. We say that a positive integer is a *semihappy number* if it is an $\mathbf{e}$-semihappy number for some $\mathbf{e}$, as above.

After introducing these concepts, we will summarize a variety of results, and indicate methods of proof, concerning fixed points and cycles of $S_{\mathbf{e}}$, heights and global heights of $\mathbf{e}$-semihappy numbers, and lengths of sequences of consecutive $\mathbf{e}$-semihappy numbers. (Received September 13, 2008)

1046-11-992 **Jasson Vindas*** (jvindas@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803-4918, and **Ricardo Estrada**, Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803-4918. *A quick distributional way to the prime number theorem.*

A distributional proof of the prime number theorem is presented. The word *distributional* refers to Schwartz distributions. The proof is based on the non-vanishing of the Riemann zeta function $\zeta(z)$ on the line $\Re e\, z = 1$, $z \neq 1$, Chebyshev's elementary estimate, and arguments from the theory of asymptotic behaviors of generalized functions. (Received September 13, 2008)

1046-11-995 **Jing Long Hoelscher*** (jlong@math.arizona.edu), Dept. of Math, University of Arizona, 617 N. Santa Rita Ave., P.O. Box 210089, Tucson, AZ 85721. *Class numbers of function fields.* Preliminary report.

This talk will focus on the class groups of function fields. First I will give a description of the p-part of the class number of a $\mathbb{Z}_p^d$ extension of a function field, which is similar to the one in the number field case. Then I will talk about recent progress towards the analogy of the Herbrand-Ribet theorem in function fields. (Received September 13, 2008)

1046-11-1007 **Emma Previato*** (ep@bu.edu), Department of Mathematics and Statistics, Boston University, Boston, MA 02215-2411, and **Drue Coles**, Dept of Math., Computer Science, Statistics, Bloomsburg University, Bloomsburg, PA 17815. *Maximal subbundles in coding theory.*

For decoding efficiency in geometric Goppa codes, rank-2 vector bundles (over the curve used in the definition of the code) could be used advantageously. For example, the computational complexity of setting up transition functions for the bundle is $O(mn^2 + l^2mn + n \cdot \text{size}F)$ for a code of length n, while $m+1$ is the dimension of a space of sections, F is the ideal that defines the curve and a "size" is defined appropriately (T. Bouganis and D. Coles, in *Lecture Notes in Comput. Sci.* **2643**, 2003). Vector bundles enter naturally: the code is the image of sums of points; by a (suitable) divisor map the curve is sent to the dual projective space of the divisor's sections, which is isomorphic to the projective space of extensions of one line bundle by another, giving the rank-2 bundle: this idea is originally due to T. Johnsen (*Int. J. Pure Appl. Math.*, 2003).This talk is a report on geometric methods intended to provide algorithms for finding maximal(-degree) subbundles, which correspond to error divisors, and examples. (Received September 13, 2008)

1046-11-1030 **Qingquan Wu*** (quwu@ucalgary.ca), Department of Math. & Stat., University of Calgary, 2500 University Drive NW, Calgary, Alberta T2N 1N4, Canada. *Computing Fundamental Units in Bicyclic Biquadratic Global Fields.*

We compute the unit group of an arbitrary bicyclic biquadratic global field K, using Kubota's method. A unified treatment is given for two different types of global field. That is, computing the unit group of K can be reduced to computing the three unit groups of the three distinct quadratic subfields of K. Our main contribution is an infinite family of examples for every possible type of unit group. These examples are independent of the constant field of K. Finally, we discuss two applications of the unit group computation; one involves the Minkowski unit in K and the other the norm of the fundamental unit in certain real quadratic function fields. (Received September 14, 2008)

1046-11-1092 **Michael Daub** and **Jackie Lang***, jlang@brynmawr.edu, and **Mona Merling**, **Natee Pitiwan**, **Allison Pacelli** and **Michael Rosen**. *Class Number Indivisibility in Function Fields.*

It is known that infinitely many number fields and 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. There are some results related to the indivisibility of class numbers of quadratic number fields, but the fields are not constructed explicitly. In a recent paper, Pacelli and Rosen explicitly constructed an infinite class of 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 an arbitrary prime ℓ, there are infinitely many function fields of any degree with class number indivisible by ℓ. (Received September 14, 2008)

1046-11-1144 **Tian Ren*** (tren@qcc.cuny.edu), 222-05 56th Avenue, Room S-245, Bayside, NY 11364, and **Robert Sczech**. *A Refinement of Stark's Conjecture Over Complex Cubic Number Fields.*

We study the first order zero case of Stark's conjecture over a complex cubic number field F. In that case, the conjecture predicts the absolute value of a complex unit in an abelian extension of F. We present a refinement of Stark's conjecture by proposing a formula (up to a root of unity) for the unit itself instead of its absolute value. (Received September 14, 2008)

1046-11-1150 **Brian Lawrence*** (BrianL@caltech.edu). *Bounding the Coefficients of $\Phi_{pqr}(x)$.*

A conjecture of Gallot and Moree states that, for all primes p, q, and r, the coefficients of the pqrth cyclotomic polynomial are bounded by $\frac{2}{3}p$. We prove this conjecture for all $p > 10^6$, assuming $p < q < r$. Furthermore, for $p > 10^{21}$, we give a formula for the largest coefficient of any cyclotomic polynomial $\Phi_{pqr}(x)$, as q and r range over all primes greater than p. Our work leaves the conjecture of Gallot and Moree open for small p. (Received September 14, 2008)

1046-11-1158 **Tewodros Amdeberhan**, Department of Mathematics, Tulane University, New Orleans, LA 70118, **Luis A Medina**, Department of Mathematics, Rutgers University, New Brunswick, NJ 08854, and **Victor H Moll*** (vhm@math.tulane.edu), Department of Mathematics, Tulane University, New Orleans, LA 70118. *Asymptotics of the p-adic valuations of solutions of linear recurrences.*

Let p be a prime and Q a polynomial with integer coefficients. Define the sequence x[n] by x[0] =1 and x[n] = Q[n]x[n-1]. Under certain conditions on Q, the p-adic valuation of x[n] grows linearly with n. The slope is

related to the number of roots of Q in the p-adic ring Z[p]. We present some conjectures on the corresponding error term. (Received September 14, 2008)

1046-11-1159 **Jennifer Paulhus*** (paulhus@math.ksu.edu), Kansas State University, Department of Mathematics, Manhattan, KS 66506. *Decomposing Jacobian varieties using automorphism groups.*

Jacobian varieties of curves which have many elliptic curves in their decompositions have interesting applications to rank and torsion questions. Given a curve X with automorphism group G, idempotent relations in the group ring $\mathbb{Q}[G]$ lead to decompositions of the Jacobian of X. In this talk we briefly explain the techniques involved and some recent results obtained from these techniques. (Received September 14, 2008)

1046-11-1175 **Pavel Guerzhoy*** (pavel@math.hawaii.edu), Department of Mathematics, University of Hawaii at Manoa, 2565 McCarthy Mall, Keller 401A, Honolulu, HI 96822. *Holomorphic parts of weak harmonic Maass forms and Eichler cohomology.*

I will discuss a way to define holomorphic parts of weak harmonic Maass forms in terms of Eichler cohomology. In this way, one avoids working with Maass forms, and introduces periods of weakly holomorphic modular forms instead. A generalization of Haberland's identity, a connection to the algebraicity of the Fourier coefficients, and some congruences will be presented. (Received September 15, 2008)

1046-11-1196 **Jeremy Lovejoy*** (lovejoy@liafa.jussieu.fr), LIAFA, Universite Denis Diderot - Paris 7, Case 7014, 75205 Paris Cedex 13, France, and **Kathrin Bringmann**. *Overpartitions and class numbers of binary quadratic forms.*

We study the number of overpartitions with even rank minus the number with odd rank. The corresponding generating function is the holomorphic part of a weight 3/2 harmonic Maass form which is closely related to Zagier's Eisenstein series and Hurwitz class numbers. This is also true if we replace the classical rank with the M2 rank. (Received September 15, 2008)

1046-11-1223 **Scott Ahlgren**, **Dohoon Choi** and **Jeremy Rouse***, 1409 West Green Street, Urbana, IL 61801. *Congruences for level four cusp forms.*

We study congruences for modular forms of half-integral weight on $\Gamma_0(4)$. Suppose that $\ell \geq 5$ is prime, that K is a number field, and that v is a prime of K above ℓ. Let $\mathcal{O}_v$ denote the ring of v-integral elements of K, and suppose that $f(z) = \sum_{n=1}^{\infty} a(n)q^n \in \mathcal{O}_v[[q]]$ is a cusp form of weight $\lambda + 1/2$ on $\Gamma_0(4)$ in Kohnen's plus space. We prove that if the coefficients of f are supported on finitely many square classes modulo v and $\lambda + 1/2 < \ell(\ell + 1 + 1/2)$, then λ is even and

$$f(z) \equiv a(1) \sum_{n=1}^{\infty} n^{\lambda} q^{n^2} \pmod{v}.$$

This result is a precise analogue of a characteristic zero theorem of Vignéras. As an application, we study divisibility properties of the algebraic parts of the central critical values of modular L-functions. (Received September 15, 2008)

1046-11-1251 **Kathrin Bringmann*** (kbringma@uni-koeln.de), Weyertal 86 - 90, 50931 Köln, Germany. *Rank-crank type PDE and non-holomorphic Jacobi forms.* Preliminary report.

In this talk I will show how Rank-Crank type PDE's (first found by Atkin and Garvan) occur naturally in the framework of non-holomorphic Jacobi forms and give an infinite family of such differential equations. As an application I obtain an infinite family of congruences for odd Durfee symbols, a partition statistic introduced by George Andrews. This is joint work with Sander Zwegers. (Received September 15, 2008)

1046-11-1264 **Richard K Guy*** (rkg@cpsc.ucalgary.ca), Department of Mathematics & Statistics, The University of Calgary, Calgary, Alberta T2N 1N4, Canada, and **Kell Cheng** and **Renate Scheidler**. *Vertical symmetries in continued fraction periods.* Preliminary report.

The period of the continued fraction expansion of $\sqrt{A^2X^2 + 2BX + C}$, where the quadratic satisfies the Schinzel condition, $0 \neq \Delta = B^2 - A^2C$ divides $4[\gcd(A^2, B)]^2$, consists of linear functions $(\alpha_i X + \gamma_i)/\beta_i$ punctuated by strings (which may be empty) which are the c.f.e. of fractions N/ν_i. The period comes in P shapes, depending on the value of X mod P, where P, N, and the products $\alpha_i\beta_i$ are all divisors of $2A$. The "horizontal" symmetry of the periods is classical, but we are also interested in the "vertical" symmetry of the γ_i and ν_i across the P residue classes. (Received September 15, 2008)

1046-11-1271 **O-Yeat Chan*** (math@oyeat.com), Dept. of Math and Stat, Chase Building, Dalhousie University, Halifax, NS B3H 3J5, Canada, and **Dante Manna** (dmanna@vwc.edu), 1584 Wesleyan Drive, Norfolk, VA 23502. *Some divisibility properties for Stirling numbers of the second kind.* Preliminary report.

We will discuss our investigations into the 2-adic valuation of Stirling numbers of the second kind. (Received September 15, 2008)

1046-11-1323 **Qiao Zhang*** (q.zhang@tcu.edu), Department of Mathematics, Texas Christian University, 2840 West Bowie Street, Fort Worth, TX 76109. *Value Distribution of Automorphic L-functions.*

The behavior of automorphic L-functions within the critical strip, especially along the critical line or at the boundary of the strip, is of great arithmetic and analytic interest. In this talk, we discuss the value distribution of these L-functions through a study of their high moments. This work generalizes the previous results over $GL(2)$. (Received September 15, 2008)

1046-11-1329 **Patrick Corn*** (pkcorn@smcm.edu), 18952 E. Fisher Rd., St. Mary's City, MD 20686. *Brauer-Manin obstructions and Sha of genus-2 jacobians.*

We report on an application of a method (due originally to van Luijk and Logan) which exhibits nontrivial elements of the Tate-Shafarevich group of the Jacobian of a genus-2 curve, by means of a Brauer-Manin obstruction on an associated K3 surface. (Received September 15, 2008)

1046-11-1349 **Becky E Hall*** (bhall@wesleyan.edu). *Membership in an Ideal in the Group Ring,* $\mathbb{Z}[GL_3(\mathbb{Z})]$.

In an effort to improve upon a computation for modular forms for $\mathrm{GL}_3(\mathbb{Z})$, a small set of generators is desired for an ideal in the group ring, $\mathbb{Z}[\mathrm{GL}_3(\mathbb{Z})]$. The notion of a Gröbner basis can be extended to such a group ring. It will be shown that under certain conditions, membership in a group ring ideal can be determined. (Received September 15, 2008)

1046-11-1382 **Paul A Loomis*** (ploomis@bloomu.edu), Department of Mathematics, Bloomsburg University, Bloomsburg, PA 17815. *More results on "sum of cubes equal to square of sums".*

Following recent work of David Pagni and John Mason, we discuss results on solutions of the Diophantine equation $(a_1 + a_2 + \cdots + a_n)^2 = a_1^3 + a_2^3 + \cdots + a_n^3$, also known as "square of sum equal to sum of cubes". (Received September 15, 2008)

1046-11-1391 **Dominic W Klyve*** (dklyve@carthage.edu), Carthage College, 2001 Alford Park Dr., Kenosha, WI 53140. *The search for base-2 Fibonacci pseudoprimes.*

An open question of Pomerance, Selfridge, and Wagstaff asks whether there is any number $n \equiv \pm 2 \pmod 5$ that is simultaneously a base-2 pseudoprime and a Fibonacci pseudoprime. This talk will discuss joint work with D. Monfre on a new computer search for such a number, extending former searches by a factor of about 100. We will present statistical data from our search, and give a heuristic for the existence of such a number, despite the failure of searches to date. (Received September 15, 2008)

1046-11-1446 **William D Taylor*** (taylorw4@unr.nevada.edu), 1619 N Virginia St, Apt 117, Reno, NV 89503. *Finding Square Roots of p-adic Numbers.*

In the study of p-adic numbers one finds that many of the operations one takes for granted on the real numbers do not work as well, or sometimes at all, in the field of p-adic numbers $\mathbb{Q}_p$. One such operation is that of finding the square root of a number. The real numbers are nicely organized into those which have real square roots (the nonnegative reals) and those whose square roots are imaginary numbers (the negative reals). The p-adic numbers, on the other hand, have a more counterintuitive nature. In fact, there are four cases one must consider when finding the square root of a p-adic number. In this paper we present what we call the r-quadratic extension of $\mathbb{Q}_p$, which we will prove is a field containing the square root of all p-adic numbers. At the same time, we will give a well-defined process for finding the square root of any given p-adic number to any degree of accuracy. The process we describe can be used for any number of purposes, including finding the general terms of second-order linear homogeneous recurrence relations of p-adic numbers. (Received September 15, 2008)

1046-11-1459 **Andrew Shallue*** (ashallue@math.ucalgary.ca), University of Calgary, Department of Mathematics and Statistics, 2500 University Drive NW, Calgary, Alberta T2N1N4, Canada, and **Eric Bach**. *Composites with large sets of strong liars.* Preliminary report.

The Miller-Rabin primality test is often used in practice to determine if an integer is prime or composite. This test generates a random $a \in (Z/(n))^*$ and then determines whether n is a strong pseudoprime to the base a.

For composite n, the set $S(n)$ of a for which the test mistakenly returns "prime" has size at most $(n-1)/4$. Our goal is to find infinite classes of composite integers with large sets $S(n)$. For example, Carmichael numbers with three prime factors, all congruent to 1 mod 4, have $S(n) = \phi(n)/4$. However, it seems difficult to prove that infinitely many exist. In this talk we present "almost Carmichael" numbers, a provably infinite class, and give lower bounds on $|S(n)|$ when n is almost Carmichael. (Received September 15, 2008)

1046-11-1518 **Sherry Gong***, Cabot Mail Center Box #291, Cambridge, MA 02138. *On a Conjecture Regarding the Coefficients of Cyclotomic Polynomials.*

Let $a_n(k)$ be the coefficient of x^k in the nth cyclotomic polynomial

$$\Phi_n(x) = \prod_{\substack{j=1 \\ gcd(j,n)=1}}^{n} (x - e^{\frac{2\pi j i}{n}})$$

Let $M(a_n(k)) = \lim_{x\to\infty} \frac{1}{x}\sum_{n\le x} a_n(k)$ be the average of $a_n(k)$, as introduced by Möller, and let

$$f_k = \frac{\pi^2}{6} M(a_n(k))k \prod_{\substack{q\le k \\ q \text{ prime}}} (q+1).$$

It was conjectured by Y. Gallot, P. Moree and H. Hommersom that the f_k are integers for all k. In this paper, we prove this conjecture. Moreover, we show that for any fixed natural number n, f_k contains n as a factor for sufficiently large k. (Received September 15, 2008)

1046-11-1526 **Nimish A Shah*** (nimish@math.tifr.res.in), Department of Mathematics, Yale University, P.O. Box 208283, New Haven, CT 06520-8283. *Expanding translates of curves and Dirichlet-Minkowski theorem on linear forms.*

We show that a multiplicative form of Dirichlet's theorem on simultaneous Diophantine approximation as formulated by Minkowski, cannot be improved for almost all points on any analytic curve on $\mathbb{R}^k$ which is not contained in a proper affine subspace. Such an investigation was initiated by Davenport and Schmidt in the late sixties.

Based on an observation by Kleinbock and Weiss, the problem reformulates as a question about equidistribution of expending translates of curves on the space of unimodular lattices on $\mathbb{R}^n$. We prove the equidistribution statement using Dani-Margulis nondivergence criterion, Ratner's classification of ergodic invariant measures, linearization techniques and new linear dynamical observations. (Received September 15, 2008)

1046-11-1530 **Tue Ngoc Ly*** (lntue@yahoo.com), 14505 Prism Circle, Apt. 303, Tampa, FL 33613. *Groups of linear functions on Zn.*

There are many problems of linear functions on finite rings. Among those are some iteration problems that are simply stated but extremely hard to prove, such as the 3x + 1 conjecture, or the greatest prime factor conjecture, that dealing with divisibility, periodicity of linear functions. Study about linear functions on finite rings may provide more information about these questions. In this presentation, I will talk about some properties and structures of groups of linear functions on the ring Zn. (Received September 15, 2008)

1046-11-1549 **John W. Hoffman**, **W. Ryan Livingston** and **Jared M. Ruiz*** (jmruiz@student.ysu.edu). *A Note on Disjoint Covering Systems of Congruences: Variations on a 2002 AIME Problem.*

A system of congruences $S = \{x \equiv a_i (\text{mod } m_i) : 1 \le i \le k\}$ is a set of k arithmetic progressions given by, $\{x = nm_i + a_i : 1 \le i \le k \text{ and } n \in \mathbb{Z}\}$. Erdös introduced the idea of such a system with the property that every integer belongs to at least one congruence in the system. In 1950, he used this type of system to solve a problem presented to him by Romanoff and called such a system a *covering system of congruences*. During an REU conducted at Youngstown State University this summer, the authors considered covering systems and some classical results about these arithmetic progressions. Two new results about covering systems were proven by the authors during this summer research. These results provide an upper bound on the number of consecutive integers which need to be checked to determine if a system is a special type of covering system. This bound is given only in terms of k, the number of congruences in the system. These results provide an analog of a theorem by R. B. Crittenden and C. L. Vanden Eynden from 1969 and are presented as solutions to some variations of a 2002 AIME Problem about painting a picket fence. (Received September 16, 2008)

1046-11-1560 **Matthew James Emerton*** (emerton@math.northwestern.edu), Northwestern University, Department of Mathematics, 2033 Sheridan Rd., Evanston, IL 60208. *Topology, representation theory, and arithmetic: three-manifolds and the Langlands program.*

The Langlands program is an extensive web of theorems and conjectures concerning the existence of both automorphic forms (objects that are related to harmonic analysis and the representation theory of Lie groups) and representations of Galois groups, and the relationships between these two kinds of mathematical objects. In this talk, I will explain some ideas from the Langlands program, and will illustrate their (perhaps surprisingly) wide range of application by describing how they can be used (following Frank Calegrai and Nathan Dunfield) to construct closed hyperbolic three-manifolds of arbitrarily large injectivity radius that are rational homology spheres. (Received September 16, 2008)

1046-11-1633 **Thomas R Hagedorn*** (hagedorn@tcnj.edu), Department of Mathematics and Statistics, The College of New Jersey, Ewing, NJ 08628-0718. *Computation of Jacobsthal's Function* $\mathbf{h(n)}$ *for* $\mathbf{n < 50}$.

Let $j(n)$ denote the smallest positive integer m such that every sequence of m consecutive integers contains an integer prime to n. Let P_n be the product of the first n primes and define $h(n) = j(P_n)$. Previously, $h(n)$ was only known for $n \leq 24$. The author has been able to calculate $h(n)$ for $n < 50$ with the use of a simple, new algorithm. (Received September 16, 2008)

1046-11-1635 **Robert Osburn*** (robert.osburn@ucd.ie), School of Mathematical Sciences, University College Dublin, Belfield, Dublin, 4, Ireland. *Gaussian hypergeometric functions.*

In 1984, Greene introduced the notion of hypergeometric functions over finite fields. Special values of these functions are of interest as they are related to Fourier coefficients of modular forms. In this talk, we discuss these developments and new results. (Received September 16, 2008)

1046-11-1642 **Pieter Rozenhart*** (pieter@math.ucalgary.ca), Department of Mathematics and Statistics, University of Calgary, 2500 University Drive NW, Calgary, Alberta T2N 1N4, Canada, and **Renate Scheidler** (rscheidl@math.ucalgary.ca), Department of Mathematics and Statistics, University of Calgary, 2500 University Drive NW, Calgary, Alberta T2N 1N4, Canada. *Tabulation of Cubic Function Fields Via Reduction.*

We discuss some recent results on tabulating cubic function fields. We give an overview of the general method for tabulating all cubic function fields over $\mathbb{F}_q(t)$ whose discriminant D has odd degree, or even degree such that the leading coefficient of $-3D$ is a non-square in $\mathbb{F}_q{}^*$, up to a given bound on $|D| = q^{\deg(D)}$. The main theoretical ingredient is a generalization of a theorem of Davenport and Heilbronn to cubic function fields, along with the reduction theory for binary cubic forms. We present numerical data for cubic function fields over $\mathbb{F}_5$ and over $\mathbb{F}_7$ with $\deg(D)$ odd, and discuss some open problems and extensions. (Received September 16, 2008)

1046-11-1655 **Asher N. Auel*** (auela@math.upenn.edu), Mathematics Department, University of Pennsylvania, 209 S 33rd St., Philadelphia, PA 19104. *Characteristic classes and root numbers for motives associated to* $\mathbf{GO}_n$. Preliminary report.

The theory of root numbers plays an important role in the study of the functional equations of L-functions of motives and of modular forms. Deligne gave an interpretation of the local root numbers of orthogonal Artin motives in terms of the Stiefel-Whitney invariants of the associated local orthogonal Galois representations. These Galois theoretic Stiefel-Whitney invariants are also expressed, via formulas of Serre and Fröhlich, in terms of the classical Hasse-Witt invariants of certain quadratic forms attached to the motive. This talk is about a new construction of cohomological invariants, generalizing the Stiefel-Whitney and Hasse-Witt invariants, for motives associated to the group of orthogonal similitudes, $\mathbf{GO}_n$, and for the line bundle-valued quadratic forms attached to these motives. I will discuss some examples coming from arithmetic geometry as well as the connection of these new invariants to root numbers. (Received September 16, 2008)

1046-11-1706 **Curtis N Cooper*** (cooper@ucmo.edu), Dept. of Math. & Comp. Sci., University of Central Missouri, Warrensburg, MO 64093. *An Identity Involving Generalized Fibonacci Numbers.*

We will present an identity involving generalized Fibonacci numbers. (Received September 16, 2008)

1046-11-1720 **Jonathan Webster*** (jwebster@math.ucalgary.ca), Univerity of Calgary: Dept of Math and Stats, 2500 University Dr. NW, Calgary, AB T2N 1N4, Canada. *Arithmetic Aspects of a Cubic Function Field in Characteristic Three.*

In this talk we present a preliminary investigation of cubic function fields in characteristic three. We choose a single parameter family of curves defined by $H(x, y) := y^3 + y^2 + F = 0$ where $F \in k[x]$ and k is a finite field

with char(k) = 3. We classify the splitting of the finite places and find the different exponent of the infinite place which allows us to calculate the genus for these curves. We also give algorithms for computing in the ideal class group (with restrictions on F). We consider these curves for their innate interest as well as applications to cryptography. (Received September 16, 2008)

1046-11-1738 **Doug Hensley*** (dhensley@math.tamu.edu), Dept Math, TAMU, mail stop 3368, College Station, TX 77840. *Polynomials that take small values at an algebraic integer.* Preliminary report.

The continued fraction expansion of $\sqrt{2}$ gives a sequence of rational approximations (p_n/q_n) to $\sqrt{2}$. But we can also look at it this way: we get a sequence of integer vectors (p_n, q_n) that are exceptionally close to being perpendicular to $(1, -\sqrt{2})$. What happens if we look for integer vectors $b = (b_0, \ldots, b_{n-1})$ exceptionally close to being perpendicular to $(1, \alpha, \ldots, \alpha^{n-1})$, when α is an algebraic integer of degree n?

If we call suitable lists b of integers *good*, we can then ask how we might find good b and what they are like. We can find them computationally by way of a lattice reduction trick. We can find them via number theory, because they have a special structure: the associated algebraic integer $\beta = \sum b_k \alpha^k$ has small *norm*, and apart from β itself, the algebraic conjugates of β have comparable absolute values.

We can also say where to find them: The *scaled coefficient lists* $|\beta|^{1/(n-1)}b$ associated with b sit very nearly on one of a finite number of surfaces λS in $\mathbb{R}^n$, where S is a hyperboloid(*) that depends on α. (Received September 16, 2008)

1046-11-1751 **M Knopp** and **H. Mawi*** (mawi@temple.edu), Temple University, Department of Mathematics, 1805 N. Broad St., Philadelphia, PA 19122. *Eichler Cohomology Theorem for Small Weights.*

Let $\mathbb{H}$ be the upper half-plane and Γ be a Fuchsian group of the first kind which is finitely generated and contains translations. Let $k \in \mathbb{R}$ and v be a multiplier system for Γ with weight k. We denote by $C^0(\Gamma, k, v)$, the set of cusp forms of weight k with multiplier system v. Let $\mathcal{P}$ be the space of functions g, which are holomorphic on $\mathbb{H}$ and which satisfy $|g(z)| < K(|z|^\rho + y^{-\sigma}),\ y = Imz > 0$, for some positive constants $K,\ \rho,$and σ. Define the *slash operator*, $|_k^v$, which acts on a function f, defined on $\mathbb{H}$, as $f|_k^v M = \bar{v}(M)ij(M,z)^{-k}f(Mz)$. A collection $\{g_M \in \mathcal{P} : M \in \Gamma\}$ is said to be a *cocycle* in weight $-k$ if $g_{M_1M_2} = g_{M_1}|_{-k}^v M_2 + g_{M_2},$ for all $M_1, M_2 \in \Gamma$, and a cocycle is called a *coboundary* if there exists $g \in \mathcal{P}$ such that $g_M = g|_{-k}^v M - g,$ for all $M \in \Gamma$. By using Petersson's principal parts condition we prove a conjecture by Knopp which states that the *Eichler Cohomolgy group of weight -k* , defined as cocycles modulo coboundaries is isomorphic to $C^0(\Gamma, k+2, \bar{v})$, if $-2 < k < 0$. (Received September 16, 2008)

1046-11-1778 **Paul Jenkins*** (jenkins@math.byu.edu), Department of Mathematics, Brigham Young University, Provo, UT 84602. *On singular values of Maass forms.*

In an influential paper, Zagier proved that generating functions for traces of singular moduli associated to polynomials in $j(\tau)$ are in fact modular forms of half integral weight on $\Gamma_0(4)$. Bringmann and Ono generalized his results to higher weights, showing that the traces of certain Maass forms appear as coefficients of Poincaré series of half integral weight. In this talk we discuss recent work on singular values of Maass forms. (Received September 16, 2008)

1046-11-1794 **Chaogui Zhang*** (czhang@marywood.edu), Department of Mathematics, Marywood University, 2300 Adams Ave, Scranton, PA 18509. *Distribution of Integers with Smooth Square Free Parts.*

Smooth integers are those with (relatively) small factors. The Dickman function describes the asymptotic probability for an integer to be smooth, which is essential in the run-time analysis of modern integer factorization algorithms such as the Quadratic Sieve and Number Field Sieve.

Integers with smooth square free parts are potentially useful for such factorization algorithms as well. The study of the asymptotic distribution of such integers will give us insight regarding the degree of possible improvements by utilizing such integers in the factorization algorithms, although currently there is no obvious or easy way for such utilization. (Received September 16, 2008)

1046-11-1817 **Chris A Kurth*** (kurthc@iastate.edu), Department of Mathematics, 396 Carver Hall, Iowa State University, Ames, IA 50011. *Modular Forms for some Noncongruence Subgroups of $SL_2(Z)$.*

The coefficients of the Fourier series of modular forms often have interesting number-theoretic properties. Modular forms for congruence groups have "bounded denominators" in the sense that if all of the Fourier coefficients are algebraic numbers (roots of integer polynomials), then they can be multiplied by some constant so that they are all algebraic integers (roots of monic integer polynomials). It is a conjecture that for noncongruence groups the opposite is true: Every purely noncongruence modular form has "unbounded denominators". In this talk we consider the conjecture for a special class of noncongruence groups, character groups, which are normal subgroups of congruence groups with finite abelian quotient. We show how to construct families of character groups for which the Unbounded Denominator Conjecture is true. (Received September 16, 2008)

1046-11-1822 **David M Harvey*** (dmharvey@cims.nyu.edu), Courant Institute of Mathematical Sciences, New York University, New York, NY 10003. *zn_poly: a library for polynomial arithmetic.* Preliminary report.

In this talk I will describe the current state of and future plans for zn_poly, a new library for polynomial arithmetic over $\mathbf{Z}/n\mathbf{Z}$, where n is a word-sized modulus. (Received September 16, 2008)

1046-11-1867 **Dmitry Kleinbock*** (kleinboc@brandeis.edu), Department of Mathematics, Brandeis University, Waltham, MA 02454, and **Gregory Margulis** and **Junbo Wang**. *Metric Diophantine approximation for systems of linear forms via homogeneous dynamics.* Preliminary report.

The goal of this work is to generalize results on strong extremality of nondegenerate submanifolds of $\mathbb{R}^n$ to the set-up of systems of linear forms. In particular, we establish 'joint strong extremality' of arbitrary finite collection of smooth nondegenerate submanifolds of $\mathbb{R}^n$. The proof is based on quantitative nondivergence estimates for quasi-polynomial flows on the space of lattices. (Received September 16, 2008)

1046-11-1909 **Matt Boylan*** (boylan@math.usc.edu), 1523 Greene St., Mathematics Dept., Columbia, SC 29208. *Recent work on Maass and modular forms.*

In this talk, the speaker will discuss recent work on the connections between Maass and modular forms. (Received September 16, 2008)

1046-11-1944 **james arthur cipra*** (cipra@math.ksu.edu), 15845 6th st rd, wamego, KS 66547. *Waring's number in a finite field.* Preliminary report.

Let p be a prime, n be an integer, $k|p^n-1$, and $\gamma(k,p^n)$ be the minimal value of s such that every number in $\mathbb{F}_{p^n}$ is a sum of s k^{th} powers (should such exist). Heilbronn conjectured that for $\mathbb{F}_p$ that $\gamma(k,p) \ll \sqrt{k}$ if there are more than 2 non-zero k^{th} powers in $\mathbb{F}_p$. Here we provide an outline of a proof for a generalization to $\mathbb{F}_{p^n}$. (Received September 16, 2008)

1046-11-1954 **Jennifer Beineke*** (jbeineke@wnec.edu), Department of Mathematics, Western New England College, 1215 Wilbraham Road, Springfield, MA 01119, **Ben Brubaker** (brubaker@math.mit.edu), MIT, Department of Mathematics, Room 2-267, Cambridge, MA 02139, and **Sharon Frechette** (sfrechet@mathcs.holycross.edu), 321 Swords Hall, Dept. of Math & Computer Science, College of the Holy Cross, Worcester, MA 01610. *Weyl Group Multiple Dirichlet Series for Type C.* Preliminary report.

Weyl group multiple Dirichlet series are Dirichlet series in several complex variables associated to a root system Φ. In this talk, we will discuss results for root systems of Type C. We will also describe some algebraic combinatorics involving Gelfand-Tsetlin patterns, used in the construction of the multiple Dirichlet series. (Received September 16, 2008)

1046-11-2030 **Eric Mortenson***, McAllister Building, Pennsylvania State University, University Park, PA 16801. *A p-adic supercongruence conjecture of Van Hamme.*

We prove a p-adic supercongruence conjecture of van Hamme by placing it in the context of the Beukers-like supercongruences of Rodriguez-Villegas. This conjecture is a p-adic analog of a formula of Ramanujan. (Received September 16, 2008)

1046-11-2048 **Ahlam E Tannouri*** (ahlam.tannouri@morgan.edu), Mathematics Department, Morgan State University, 1700 E. Cold Spring, Baltimore, MD 21251, and **Sam F Tannouri** (sam.tannouri@morgan.edu). *On some fundamental properties and applications of continued fractions to coding theory.* Preliminary report.

In number theory the field of Diophantine approximation has a long history. Many methods for solving problems in this field have been invented using continued fractions as as a stepping stone. On the new era of advanced communication, fast arithmetic on hyperelliptic curves via continued fraction will be explored as an application to coding theory. (Received September 16, 2008)

1046-11-2071 **Kiryl I Tsishchanka*** (ktsishch@depaul.edu), Department of Mathematical Sciences, DePaul University, 2320 North Kenmore Ave., Chicago, IL 60614. *On integer polynomials that are small at a given cubic irrational.*

Lagrange proved that the regular continued fraction of a real number ξ is periodic if and only if ξ is quadratic. Moreover, it is known that if $\xi = [0, \overline{a}]$, then

$$\lim_{i\to\infty} |q_i\xi - p_i|\, q_i = 1/\sqrt{D},$$

where D is discriminant of ξ and p_i/q_i is its ith convergent. In the first part of this talk we will discuss a generalization of this statement to the case $\xi = [0, \overline{a_1, \dots, a_k}], k > 1$.

Now let ξ be a cubic irrational. In the second part of the talk we will present a simple and fast algorithm to construct integer polynomials P_i of degree ≤ 2 such that $|P_i(\xi)|$ are small at ξ. There is another property of the sequence P_i which is of particular interest. Put $K_i^{(2)} = |P_i(\xi)|\|P_i\|_2^2$, where $\|\cdot\|_2$ is the ℓ^2-polynomial norm. We will show that there is a connection between $K_i^{(2)}$ and the beta distribution. (Received September 17, 2008)

1046-11-2094 **Erich Kaltofen*** (kaltofen@math.ncsu.edu), Dept. Mathematics, Campus Box 8205, NCSU, Raleigh, NC 27695. *Rump's model problem and the computer search for records in number theory.* Preliminary report.

Rump's model problem is the problem to globally minimize real polynomial product 2-norms:

$$\begin{aligned}\mu_n = \min\{\|PQ\|_2 \mid P, Q \in \mathbb{R}[z], \|P\|_2 = \|Q\|_2 = 1 \\ \text{and } \deg(P) = \deg(Q) = n-1\}.\end{aligned}$$

In our ISSAC 2008 paper we compute upper bounds for μ_n for $n \le 79$ and certified lower bounds for $n \le 14$. It is possible from the optimal polynomials P and Q to compute integer polynomials with good lower bounds for the maximal single factor height ratio

$$\begin{aligned} c_n = \max_{F,\,G}\ & \chi_n \\ \text{s. t. } & \min(\|F(z)\|_\infty, \|G(z)\|_\infty) = \chi_n \|F(z)\cdot G(z)\|_\infty \\ & F, G \in \mathbb{Z}[z] \ \textit{irreducible}, \deg(F) + \deg(G) = n \end{aligned}$$

and integer polynomials with Mahler measure near 1 [Lehmer's problem]. My talk will describe our computational and search strategies, including those suggested by David Boyd and Lihong Zhi, and what polynomials I have found so far. (Received September 17, 2008)

12 ► *Field theory and polynomials*

1046-12-193 **Jorge Maciel*** (maciel@cims.nyu.edu), BMCC-The City University of New York, 199 Chambers Street, New York, NY 10007. *A topology on the Galois group.*

Let K be a field and E be a Galois extension of K. The Fundamental Theorem of Galois Theory provides a bijection between the set of intermediate fields $K \subseteq F \subseteq E$ and the set of subgroups of $Gal(E/K)$, when E is a finite Galois extension of K. We introduce **The Finite Abelian Topology** on $Gal(E/K)$ and show that the Fundamental Theorem of Galois Theory can be extended to any infinite Galois extension E of K if the Galois group $Gal(E/K)$ is provided with this topology. (Received August 16, 2008)

1046-12-278 **Pamela Kosick*** (kosick@math.udel.edu) and **Robert S Coulter**. *Commutative semifields via Dembowski-Ostrom polynomials.*

A finite semifield R is a non-associative division ring. Finite commutative semifields of odd order are in a one-to-one correspondence with planar Dembowski-Ostrom (DO) polynomials over finite fields as their multiplication gives rise to a planar DO polynomial and every planar DO polynomial gives rise to a finite commutative semifield. Our research centers around the form of the planar DO polynomials, and using this to find and discriminate between new examples. (Received September 14, 2008)

1046-12-284 **Crystal Clough*** (cloughcl@email.uc.edu), Dept of Mathematics, ML 0025, 839 Old Chemistry, Cincinnati, OH 45221. *Square-Vinegar Signature Scheme.*

We propose a digital signature scheme based on multivariate polynomials. The Square-Vinegar system can be much faster than similar schemes by utilizing odd characteristic and a simpler core map. These changes are possible due to the interaction of Gröbner basis algorithms and field equations. Our claims are supported by extensive experiments, which reveal that the relationship between algebraic attacks and the degree of the core map is more intricate than previously thought. (Received August 25, 2008)

1046-12-623 **Andrew Schultz*** (andrew.c.schultz@gmail.com), 1409 W. Green Street, Urbana, IL 61801. *Hilbert 90 for Finite Abelian Extensions.*

Hilbert's Satz 90 is a classic result for cyclic Galois extensions which has been generalized both cohomologically and K-theoretically. In this talk we give a generalization of Hilbert 90 which has the same flavor as the original – describing a certain minimal kernel result – but which applies to all finite abelian extensions. (Received September 09, 2008)

1046-12-898 **V Ravi Srinivasan*** (varadhu_ravi@ou.edu), 601, Elm avenue, PHSC 423, Department of Mathematics, University of Oklahoma, Norman, OK 73019-0315. *On Certain Towers of Extensions by Antiderivatives.* Preliminary report.

Let $\mathbf{F}$ be a characteristic zero differential field with an algebraically closed field of constants, $\mathbf{E} \supset \mathbf{F}$ be a no new constant extension by antiderivatives of $\mathbf{F}$ and let $\mathfrak{y}_1, \cdots, \mathfrak{y}_n$ be antiderivatives of $\mathbf{E}$. The antiderivatives $\mathfrak{y}_1, \cdots, \mathfrak{y}_n$ of $\mathbf{E}$ are called J-I-E antiderivatives if $\mathfrak{y}_i' \in \mathbf{E}$ satisfies certain conditions. We will discuss a new proof for the Kolchin-Ostrowski theorem and generalize this theorem for a tower of extensions by J-I-E antiderivatives and use this generalized version of the theorem to classify the finitely differentially generated subfields of this tower. In the process, we will show that the J-I-E antiderivatives are algebraically independent over the ground differential field. An example of a J-I-E tower is extensions by iterated logarithms. We will discuss the normality of extensions by iterated logarithms and produce an algorithm to compute the finitely differentially generated subfields of these extensions. For further information please visit http://math.ou.edu/$\sim$ vsrinivasan/Thesis-I.pdf (Received September 12, 2008)

1046-12-1387 **Daniel C Smith*** (smithdc@indiana.edu), Daniel C Smith, Indiana University, Department of Mathematics, Bloomington, IN 47405. *The Limits of the Attack on SFLASH.*

In 2003, the NESSIE consortium selected SFLASH as a recommended public key signature scheme. In 2007, Dubois, Fouque, Shamir, and Stern discovered an attack which completely breaks the signature scheme. This attack undermines not only the security of SFLASH and C^{*-} but the security of other multivariate public key systems which are designed with a similar philosophy. The attack relies on a multiplicative symmetry of the encryption mapping. We give a comprehensive classification of encryption mappings with this multiplicative symmetry, prove that the method of projection, as suggested by Ding, safeguards the scheme from the attack of Dubois et al., and show that the attack cannot be applied to the more general HFE setting. (Received September 15, 2008)

1046-12-1832 **Laurel Miller-Sims*** (millerlg@math.mcmaster.ca), Department of Mathematics & Statistics, McMaster University, 1280 Main St. W, Hamilton, ON L8S 4K1, Canada. *Hilbert's Seventeenth Problem in Valued Fields.*

A generalized version of Hilbert's seventeenth problem asks for a characterization of those rational functions over the reals that, respectively, take non-negative values, positive values or vanish on a given semi-algebraic set. Valued fields are natural structures in which to formulate analogues of this question as we may replace the notions of being non-negative and positive with the notions of having non-negative and positive valuation. In particular, we study Hilbert's seventeenth problem in certain model-complete theories of valued fields. Given a valued field, possibly with additional structure such as an ordering or derivation, $(K, v, \dots)$ and a (first-order) definable subset S of K^n we find a subring A of $K(X) = K(X_1, \dots, X_n)$, depending on S and the structure on K, and an ideal B of A such that $f \in K(X)$ is integral-definite on S if and only if f is in the integral closure of A and f is infinitesimal-definite on S if and only if f is in the integral closure of B. While the results are algebraic the proofs are model-theoretic in nature. (Received September 16, 2008)

1046-12-1953 **Gregory V Bard*** (bard@fordham.edu), Department of Mathematics, John Mulcahey Hall Room 421, Fordham University, The Bronx, NY 10458. *Solving an Intellectual Property Problem via A System of Polynomial Equations over GF(2).* Preliminary report.

Suppose there is some circuit which is believed to be functionally identical to some other circuit, i.e. equal to it for all possible inputs. All digital circuits can be represented as systems of polynomial equations, and searching for a solution to $p(x) + q(x) = 1$ is logically equivalent to the question $\exists x$ st $p(x) \neq q(x)$.

However, if one does not know which inputs of one represent which inputs of the other then the problem becomes much harder. For n inputs, there are $n!$ possible permutations, e.g. $n!$ instantiations of the problem in the previous paragraph would have be solved. However, I will present a technique that will solve the system with $\log n$ additional variables in the system of equations, and only 1 instantiation. (Received September 16, 2008)

1046-12-2066 **Aaron Lauve*** (lauve@math.tamu.edu), Texas A&M University, Department of Mathematics, MS 3368, College Station, TX 77843-3368, and **Christophe Reutenauer** (reutenauer.christophe@uqam.ca). *Rational and irrational series over the free group.*

A curious identity of Euler goes as follows: the sum of x^k over all $k \in \mathbb{Z}$ is zero. Coming to grips with the meaning of this identity leads to a new characterization of the free skew field (extending the work of Duchamp and Reutenauer) inside the space of functions on the free group. Using results from automata theory, we further deduce that every Malcev-Neumann series over the free group has a rational expression without simplification. (Received September 17, 2008)

13 ► Commutative rings and algebras

1046-13-20 **Marshall Hampton*** (mhampton@d.umn.edu), SCC 140, UMD, 1117 University Dr., Duluth, MN 55812. *Solutions, bounds, and finiteness of polynomial systems in Sage.*

Systems of polynomial equations can be studied with many tools, both symbolic and numerical, such as Groebner bases, resultants, numerical homotopy continuation methods, and tropical geometry/BKK theory. Sage provides a unified platform for all of these computations by integrating packages such as Singular, Gfan, PHCpack, and cddlib (among many others). I will provide an overview of how these tools can be combined through example systems from the n-body and n-vortex problems. (Received May 25, 2008)

1046-13-22 **Aaron B Adcock*** (Aaron.Adcock@ttu.edu), Dept of Math and Stats, Mail Stop 1042, Texas Tech University, Lubbock, TX 79409. *Vector Invariants of Elementary Abelian p-Groups.* Preliminary report.

Let $\rho : G \hookrightarrow GL(n, F)$ be a faithful representation of a finite group G over a field F. It induces an action of the group on the vector space $V = F^n$, thus on the dual space, and hence on the symmetric algebra on the dual, denoted by $F[V]$. The subring of invariant polynomials is denoted by $F[V]^G$. If $n = 2$ and F a finite field of characteristic p and order $q = p^s$, then a p-Sylow subgroup G of $GL(2, F)$ consists of all upper triangular matrices with 1's on the diagonal. This is then an elementary abelian p-group of rank s. Its invariants form a polynomial ring. We are interested in the n-fold vector invariants of this representation. As n increases these rings become more and more complicated, e.g., if $n \geq 3$ then the invariants are no longer Cohen-Macaulay. Nevertheless, we are able to present a complete generating set of these invariants. Furthermore, we expect that we can generalize our results to vector invariants of arbitrary p-groups. This work is done under the supervision of Prof. Dr. Mara D. Neusel and supported by the Barry M. Goldwater Foundation. (Received June 03, 2008)

1046-13-99 **Oleg Golubitsky**, **Marina Kondratieva** and **Alexey Ovchinnikov*** (aiovchin@math.uic.edu), University of Illinois at Chicago, Department of Mathematics, Statistics, and Computer Science, Chicago, IL , and **Agnes Szanto**. *Estimates for orders of derivatives in differential Nullstellensatz.*

We discuss the first known upper bound for orders of derivatives in the effective version of the differential Nullstellensatz. If one differentially prolongs a system of partial algebraic differential equations up to this bound, one can test if the original differential system is consistent applying only algebraic elimination to the prolonged system. In this formulation, the problem was originally posed by Seidenberg in 1956 but no complete solution was given. Our solution is via analysing differential elimination algorithms. (Received August 26, 2008)

1046-13-179 **Hwankoo Kim*** (hkkim@hoseo.edu), Department of Information Security, Hoseo University, A-San, Chung-Nam 336-795, South Korea. *Some characterizations of generalized GCD domains.*

In this presentation, we give several module-theoretic characterizations of generalized GCD domains. For example, we show that an integral domain R is a generalized GCD domain if and only if the semi-divisoriality and flatness are equivalent for torsion-free R-modules if and only if every w-fnite w-module is projective if and only if R is w-Prüfer (in the sense of Zafrullah). We also characterize when a pullback R of a certain type is a generalized GCD domain. (Received August 12, 2008)

1046-13-237 **Olivier Kwegna Heubo*** (oheubo@nmsu.edu), New Mexico State university, Department of Mathematical sciences, Las Cruces, NM 88003-8001. *Kronecker function rings of transcendental field extensions.*

We consider an extension F/D where F is a field and D a subring of F, we denote by $\Sigma(F/D)$ the set of all valuation rings V such that $D \subseteq V \subseteq F$ and V has quotient field F. We study the rings on the form

$\bigcap_{V \in \Sigma(F/D)} V^b$, where V^b is the trivial extension of V. We admit the possibility that D is a field, D is not integrally closed and F is not the quotient field of D. Therefore the class of rings considered in this context are more general than the classical Kronecker function rings and is in fact an instance of Halter-Koch's notion of an F-function ring.

A case of special interest is when we consider a field extension F/K that has at most countable transcendence degree and the ring D to be a finitely generated K-sub algebra of F. We define,

$$H := \bigcap_{V \in \Sigma(F/D)} V^b.$$

We investigate the ideal structure of H by using the topological structure of the Zariski-Riemann space $\Sigma(F/D)$. We show that for any pair of nonnegative integers d and h there are infinitely many prime ideals of dimension d and height h that are minimal over any proper nonzero finitely generated ideal of H. (Received August 21, 2008)

1046-13-271 **Louiza Fouli*** (lfouli@math.utexas.edu), 1 University Station, C1200, Austin, TX 78712, and **Claudia Polini** and **Bernd Ulrich**. *The core of points and the Cayley-Bacharach Property.*

We will discuss the shape of the core of an ideal in a Cohen-Macaulay ring and in particular we will focus on the following situation: Let k be an infinite field and let $X = \{P_1, \ldots, P_s\}$ be a set of s reduced points in $\mathbb{P}^n_k$. Let $R = k[x_0, \ldots, x_n]/I_X$ be the homogeneous coordinate ring of $X \subset \mathbb{P}^n_k$ and $\mathfrak{m} = (x_0, \cdots, x_n)$ the homogeneous maximal ideal of R. We present a formula for core($\mathfrak{m}$) and show a connection between the shape of core($\mathfrak{m}$) and the Cayley-Bacharach property of X. (Received September 14, 2008)

1046-13-297 **Bonnie B. Smith*** (bsmith17@nd.edu), Department of Mathematics, 255 Hurley Building, University of Notre Dame, Notre Dame, IN 46556. *The Core of Monomial Ideals in $K[x, y]$.*

The core of an ideal is defined to be the intersection of all its reductions. A reduction of I is a subideal $J \subseteq I$ with the property that $JI^r = I^{r+1}$ for some integer $r \geq 0$. The core arises naturally in the context of the Briançon-Skoda theorem, as well as in algebraic geometry, and in many cases is connected to adjoint (multiplier) ideals. One would like to have a combinatorial description of the core of monomial ideals. I provide such a description for the case of $\mathfrak{m}$-primary monomial ideals in a polynomial ring $K[x, y]$. (Received August 25, 2008)

1046-13-348 **Christina Eubanks-Turner*** (ceturner@louisiana.edu), University of Louisiana @ Lafayette, Department of Mathematics, P.O.Box 41010, Lafayette, LA 70504, and **Melissa Luckas** and **Serpil Saydam**. *Prime Ideals in Low-Dimensional Mixed Polynomial/Power Series Rings.* Preliminary report.

This talk will present research that examines prime spectra of low-dimensional mixed polynomial/power series rings over one-dimensional rings. In particular, we characterize the partially ordered set of prime ideals of $R[[x]][\frac{g}{f}]$, where $\{f, g\}$ is a $R[[x]]$-sequence and R is either a one-dimensional countable PID or an order in an algebraic number field. (Received August 27, 2008)

1046-13-410 **Marie A Vitulli*** (vitulli@uoregon.edu), Department of Mathematics, 1222 University of Oregon, Eugene, OR 97403-1222. *Seminormality and Weak Normality.*

In this talk we outline the history of the twin theories of weak normality and seminormality for commutative rings and algebraic varieties with an emphasis on the recent developments in these theories over the past fifteen years. We discuss both the geometric and arithmetic consequences of these notions and for the most part limit our attention to reduced Noetherian rings. We discuss the original definitions via gluings, Hamann's criterion for seminormality and Swan's refinement, connections with the Picard group including a recent simplified treatment, universal mapping properties, systems of weak subintegrality, an elementwise criterion of weak seminormality, a recent geometric interpretation of the elementwise criterion and other developments, as time permits. (Received September 01, 2008)

1046-13-421 **Wenyuan Wu*** (wenyuanwu@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824. *F,G,H,I Bases for Polynomial Rings and their Relations.*

Gröbner basis and H-basis are well known in polynomial algebra. Formally integrable basis and Involutive basis are derived from the formal theory of partial differential equation. The relations among these bases will be discussed in this talk.

We show that Numerical Linear Algebra methods (specifically the Singular Value Decomposition), coupled with the geometric theory of differential equations, yields a new numerical approach in computational algebraic geometry. Unlike existing symbolic methods for exact systems, it could be applied to compute such bases even for approximate systems arising in applications. Other relative applications will also be discussed in this talk. (Received September 02, 2008)

1046-13-425 **Daniel D. Anderson*** (dan-anderson@uiowa.edu), University of Iowa, Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52242-1419, and **Sangmin Chun** (sangmi-chun@uiowa.edu), University of Iowa, Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52242-1419. *Finitely Generated Monoids of Fractional Ideals.*

Let R be a commutative ring with identity. Let $\bar{F}(R)$ be the monoid of R-modules of $T(R)$, the total quotient ring of R, under multiplication. Let $F(R)$ (resp., $F^*(R)$, $P(R)$) be the submonoids of fractional ideals (resp., finitely generated fractional ideals, principal fractional ideals) of R. We give necessary and sufficient conditions for these four monoids and their respective positive cones consisting of the respective integral ideals to be finitely generated. (Received September 02, 2008)

1046-13-478 **David F Anderson** and **Ayman R Badawi*** (abadawi@aus.edu), American University of Sharjah, Dept. of Math, P.O. Box 26666, Sharjah, 00000, United Arab Emirates. *On n-absorbing ideals of commutative rings.* Preliminary report.

Let R be a commutative ring with $1 \neq 0$ and n a positive integer. In this paper, we study two generalizations of a prime ideal. A proper ideal I of R is called an n-absorbing (resp., strongly n-absorbing) ideal if whenever $x_1 \cdots x_{n+1} \in I$ for $x_1, \ldots, x_{n+1} \in R$ (resp, $I_1 \cdots I_{n+1} \subseteq I$ for ideals $I_1, \ldots, I_{n+1}$ of R), then there are n of the x_i's (resp., n of the I_i's) whose product is in I. We investigate n-absorbing and strongly n-absorbing ideals, and we conjecture that these two concepts are equivalent. In particular, we study the stability of n-absorbing ideals with respect to various ring-theoretic constructions and study n-absorbing ideals in several classes of commutative rings. For example, in a Noetherian ring every proper ideal is an n-absorbing ideal for some positive integer n, and in a Prüfer domain, an ideal is an n-absorbing ideal for some positive integer n if and only if it is a product of prime ideals. (Received September 04, 2008)

1046-13-603 **Bruce M Olberding*** (olberdin@nmsu.edu), Department of Mathematical Sciences, Las Cruces, NM 88003-8001. *Derivations, formal fibers and bad Noetherian rings.* Preliminary report.

If R is a commutative ring that is finitely generated as an algebra over a field or the ring of integers, then the integral closure of R is a finitely generated R-module, and this implies the the completions of the localizations of R at maximal ideals have no nilpotent elements; i.e., that such localizations are analytically unramified. However, local Noetherian rings in general need not be analytically unramified, a fact that often poses technical difficulties in dealing with Noetherian rings that are not integrally closed. In this talk we look at a circle of ideas involving derivations, analytically ramified Noetherian rings, and the generic formal fibers of Noetherian rings, and from these relationships we deduce the existence of large classes of analytically ramified Noetherian rings in (arguably) natural settings. Although the main application here is to Noetherian rings, the techniques are mostly non-Noetherian. (Received September 08, 2008)

1046-13-787 **Alexander B. Levin*** (levin@cua.edu), Department of Mathematics, The Catholic University of America, Washington, DC 20064. *Generalized Gröbner Basis Method for Computing Multivariate Hilbert Polynomials.*

Let D be a ring of polynomials in m variables $X_1, \ldots, X_m$ over a field K and let a partition of the set $\{X_1, \ldots, X_m\}$ into p disjoint subsets be fixed, so that D can be treated as a filtered ring with the natural p-dimensional filtration associated with the partition. We introduce a special type of reduction in a finitely generated free D-module and develop the corresponding generalized Gröbner basis technique that allows one to prove the existence and find invariants of a dimension polynomial in p variables associated with a finitely generated D-module M. We also prove the existence of a multivariate dimension polynomial associated with arbitrary D-submodule of M and outline a method of computation of multivariate dimension polynomials. (Received September 11, 2008)

1046-13-813 **Nicholas R. Baeth*** (baeth@ucmo.edu), W. C. Morris 213, Department of Mathematics and Comp. Sci., University of Central Missouri, Warrensburg, MO 64093, and **Melissa R. Luckas**. *Ranks of Indecomposable Torsion-free Modules and a Krull-Schmidt Theorem.*

Let M be a finitely generated torsion-free module over a one-dimensional reduced Noetherian ring R with finitely generated normalization. The *rank* of M is the tuple of vector space dimensions of M_P over each field R_P, where P ranges over the minimal prime ideals of R. Given the existence of a bound on the ranks of all indecomposable finitely generated torsion-free R-modules, what ranks occur? Partial answers to this question have been given by several authors over the past forty years. We now provide a final answer by giving a concise list of the ranks of indecomposable modules. Then, using these ranks, we are able to give a measure of how close the category of torsion-free R-modules is to having the Krull-Schmidt property. (Received September 11, 2008)

1046-13-814 **Roger Wiegand*** (rwiegand@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588-0130. *Semigroups of torsion-free modules.* Preliminary report.

Let $(R, \mathfrak{m})$ be a commutative, Noetherian, local domain of dimension one, and assume that the $\mathfrak{m}$-adic completion of R has no non-zero nilpotent elements. Given a family $\mathcal{S}$ of finitely generated R-modules, with $\mathcal{S}$ closed under finite direct sums and under isomorphism, we consider the semigroup $\mathrm{V}(\mathcal{S})$ of isomorphism classes of elements in $\mathcal{S}$, with the operation induced by the direct sum. In earlier work by the author and others, a complete set of invariants was given for the semigroup $\mathrm{V}(R\text{-mod})$, where R-mod is the class of *all* finitely generated modules. For the class $\mathcal{F}$ of *torsion-free* finitely generated modules, the semigroup $\mathrm{V}(\mathcal{F})$ has so far defied description, though some progress has been made. For example, the description is relatively simple when each analytic branch has infinite Cohen-Macaulay type. In this talk I will discuss what is known about $\mathrm{V}(\mathcal{F})$ and what remains to be done. (Received September 11, 2008)

1046-13-851 **Gabriel Picavet*** (Gabriel.Picavet@math.univ-bpclermont.fr), Laboratoire de Mathématiques, Université Blaise Pascal, 63177 Aubiére, France, and **D. E. Dobbs** (dobbs@math.utk.edu), Department of Mathematics, University of Tennessee, Knoxville, Knoxville, TN 37996-1300. *Straight rings, II.* Preliminary report.

In the paper entitled "Straight rings", we defined a class of rings that are related to divided and going-down rings. A ring morphism $A \to B$ is said to be prime if B/PB is (A/P)-torsion-free for each $P \in \mathrm{Spec}(A)$. A ring extension $R \subseteq S$ is called straight if each of its subextensions is prime. A ring A is dubbed extensionally straight if A is straight in $\mathrm{Tot}(A)$ and a straight ring if A/P is extensionally straight for each $P \in \mathrm{Spec}(A)$. A straight domain is nothing but an extensionally straight domain. The following implications hold for rings: Locally divided $\Rightarrow$ straight $\Rightarrow$ going-down. We give new characterizations of straight rings by using primary and (or) primal decompositions of ideals. Then we give some information on straight rings within the quasi-Prüfer domain and i-domain contexts. Straight domains have properties similar to the divided property that are understood better by introducing the concepts of almost-divided and quasi-divided domains. (Received September 12, 2008)

1046-13-855 **D. E. Dobbs**, Department of Mathematics, University of Tennessee, Knoxville, Knoxville, TN 37996-1300, and **Gabriel Picavet** and **Martine Picavet-L'Hermitte*** (Martine.Picavet@math.univ-bpclermont.fr), Laboratoire de Mathématque, Université Blaise Pascal, 63177 Aubière, France. *On the maximal cardinality of chains of intermediate rings.* Preliminary report.

In earlier papers, we have considered the property for a commutative unital ring of having only finitely many (unital) subrings. This study concludes here with the characterization of rings having only finite chains of subrings. In fact, we prove that these two properties are equivalent, along with the following result. A commutative unital ring R with prime ring F has only finite chains of subrings if and only if R has only finitely many subrings, if and only if $R = F[t_1, \ldots, t_n]$, where $F[t_i]$ has only finite chains of subrings for each i, if and only if $R = F[t_1, \ldots, t_n]$, where $F[t_i]$ has only finitely many subrings for each i. A sufficient condition for the existence of an infinite chain of (unital) subalgebras is as follows. Let $R \subset T$ be a ring extension such that T is a finitely generated R-module, R is not a total quotient ring and $(R : T) = 0$. Then there exists a denumerable chain of R-subalgebras of T. (Received September 12, 2008)

1046-13-862 **Peter Vamos** (P.Vamos@exeter.ac.uk), School of Mathematical Sciences, University of Exeter, Exeter, EX4 4QE, England, and **Sylvia Wiegand*** (swiegand1@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588-0130. *Block diagonalization and 2-unit sums of matrices over Prufer domains.* Preliminary report.

We show that matrices over a large class of integral domains are equivalent to almost diagonal matrices. Here, an "almost diagonal" matrix has all its nonzero entries within blocks along the diagonal; the sizes of the diagonal blocks are determined by the size of the class group of the integral domain. This result is a generalization of a 1972 result of L. S. Levy for Dedekind domains. For integral domains in the class we study, we obtain also a partial answer to the question: For which n is every $n \times n$ square matrix a sum of two invertible matrices? (Received September 12, 2008)

1046-13-930 **David F. Anderson*** (anderson@math.utk.edu), Department of Mathematics, University of Tennessee, Knoxville, TN 37996-1300, and **D. D. Anderson** (dan-anderson@uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52242. *Nonunique Factorization in Integral Domains.* Preliminary report.

We will discuss several unifying concepts for the theory of nonunique factorization in integral domains based on relations on the set of irreducible elements of the domain. (Received September 12, 2008)

1046-13-939 **Jason Greene Boynton** and **Jim Coykendall*** (jim.coykendall@ndsu.edu), Department of Mathematics, North Dakota State University, Fargo, ND 58105-5075. *Atomicity of certain pullback constructions.*

The authors consider certain pullback constructions in the spirit of $\mathrm{Int}(E, D)$. It is well known that if E is a finite set, then $\mathrm{Int}(E, D)$ is nonatomic. Since $\mathrm{Int}(E, D)$ may be defined by a conductor square, it is natural to ask (when considering factorizations questions in particular) if this nonatomicity property persists in the more general setting. The authors show that although nonatomicity is "usually" to be expected in the more general case, certain restrictive conditions do allow atomicity to be forced. (Received September 12, 2008)

1046-13-982 **Sonja Mapes*** (mapes@math.columbia.edu), Dept. of Mathematics, Columbia University, room 509, MC 4406, 2990 Broadway, New York, NY 10027. *Finite atomic lattices and resolutions of associated monomial ideals.* Preliminary report.

The minimal free resolution of a monomial ideal can be expressed in terms of the LCM lattice of the ideal. It has also been shown that given a finite atomic lattice L one can construct certain monomial ideals M whose LCM lattice is L. This talk will explore the relationship between LCM lattices with similar associated monomial ideals and their resolutions. (Received September 13, 2008)

1046-13-1075 **Cynthia J Woodburn*** (cwoodbur@pittstate.edu), Mathematics Department, Pittsburg State University, 1701 S. Broadway, Pittsburg, KS 66762. *The Local Case Sub-algorithm for Suslin's Stability Theorem.* Preliminary report.

The result from commutative algebra known as Suslin's Stability Theorem states that the subgroup of the general linear group $GL_m(R)$ (the set of all $m \times m$ invertible matrices with entries from the ring R) which is generated by the set of elementary matrices, is equal to the special linear group $SL_m(R)$, whenever R is a polynomial ring in n variables over a field and m is at least three. An algorithmic version of Suslin's Stability Theorem exists due to Park and Woodburn. A mathematical consequence is that any $3 \times 3-$ (or larger) multivariate polynomial matrix with determinant one can be written as a finite product of elementary matrices. (Recall that an elementary matrix is a matrix that differs from the identity in at most one off-diagonal entry.) A consequence to the area of multi-dimensional digital signal processing is that a filter bank can be replaced with a cascade of simpler filters significantly reducing the number of arithmetical computations which must be carried out. An improvement to the local case sub-algorithm of the Park-Woodburn algorithm will be presented. (Received September 14, 2008)

1046-13-1133 **Thomas G. Lucas*** (tglucas@uncc.edu), Dept. of Mathematics and Statistics, University of North Carolina Charlotte, Charlotte, NC 28223. *Generally t-linkative domains.* Preliminary report.

An overring T of an integral domain R is t-linked over R if for each finitely generated ideal I of R, $(R : I) = R$ implies $(T : IT) = T$. If each overring is t-linked, then R is said to be t-linkative, and R is super t-linkative if each overring is t-linkative. The focus here is on the notion of generally t-linkative domains: R is said to be generally t-linkative, if the generalized ring of quotients $R_{\mathcal{F}}$ is t-linkative for each finite type system of ideals $\mathcal{F}$. In general, R is generally t-linkative if and only if for finite type systems $\mathcal{F}$ and $\mathcal{G}$, both $R_{\mathcal{F}}$ and $R_{\mathcal{G}}$ are flat over R and $R_{\mathcal{F}} = R_{\mathcal{G}}$, implies $\mathcal{F}$ and $\mathcal{G}$ have the same saturation. For Noetherian domains, there is no difference between being super t-linkative and generally t-linkative, each is equivalent to the domain in question being either one-dimensional or a field. In contrast, a one-dimensional Mori domain is generally t-linkative but need not be super t-linkative, and there are two-dimensional Mori domains that are generally t-linkative. (Received September 14, 2008)

1046-13-1197 **Livia Hummel*** (hummell@uindy.edu), Lilly Hall 215, 1400 Hanna Ave, Indianapolis, IN 46227, and **Thomas Marley**. *The Gorenstein property for coherent rings.*

Answering a question posed by Glaz, Hamilton and Marley used Čech cohomology to introduce a theory of non-Noetherian Cohen-Macaulay rings for which coherent regular rings are Cohen-Macaulay. A natural question to ask is whether there is a theory of Gorenstein rings that not only agrees with the Noetherian case, but for which coherent regular rings are Gorenstein, and coherent Gorenstein implies Cohen Macaulay. Using the notion of

Gorenstein dimension (introduced by Auslander and Bridger), and a generalized form of the Auslander-Bridger formula for coherent rings, we present a theory of non-Noetherian Gorenstein rings satisfying these criterion. (Received September 15, 2008)

1046-13-1204 **Silvana Bazzoni*** (bazzoni@math.unipd.it), Dipartimento di Matematica Pura e Applicata, 35121 Padova, Italy. *Finitistic projective and flat dimensions of commutative rings.*

A famous result by Lazard states that every flat module is a direct limit of finitely generated projective modules.

We investigate the problem of extending Lazard's Theorem to the class of modules of finite flat dimension.

By means of a condition on the finitistic flat dimension of the total quotient ring, we characterize the commutative rings for which every module of flat dimension at most one is a direct limit of finitely presented modules of projective dimension at most one. We note that this property is satisfied by integral domains, while it fails for some classes of noetherian rings.

Moreover we show that there exist local noetherian domains admitting modules of flat dimension two, which are not direct limit of modules of projective dimension at most two. (Received September 15, 2008)

1046-13-1207 **Kuei-Nuan Lin*** (link@purdue.edu), 150 N. University St., West Lafayette, IN 47907. *Diagonal ideals of determinantal rings.*

Let k be a field, $m \leq n$ positive integers, $X = (x_{ij})$ an m by n matrix of variables over k, $I_m(X)$ the ideal of $k[\{x_{ij}\}]$ generated by the maximal minors of X, and $R = k[\{x_{ij}\}]/I_m(X)$. We consider the diagonal ideal $\mathbb{D}$ of R, defined via the exact sequence

$$0 \longrightarrow \mathbb{D} \longrightarrow S = R \otimes_k R \overset{\text{mult.}}{\longrightarrow} R \longrightarrow 0.$$

Recall that $\mathcal{R}(\mathbb{D}) \otimes_S k$ is the homogeneous coordinate ring of the secant variety of the determinantal variety $V(I_m(X)) \subset \mathbb{P}_k^{mn-1}$, where $\mathcal{R}(\mathbb{D})$ denotes the Rees algebra of $\mathbb{D}$. It is classically know that the secant variety is all of projective space in this case. We extend this fact by showing that $\mathbb{D}$ is an ideal of linear type, which means that the natural map from the symmetric algebra $\mathrm{Sym}(\mathbb{D})$ onto the Rees algebra $\mathcal{R}(\mathbb{D})$ is an isomorphism. (Received September 15, 2008)

1046-13-1229 **John D. LaGrange***, School of Natural Sciences, Indiana University Southeast, New Albany, IN 47150. *The annihilator condition for finite commutative rings.* Preliminary report.

With the exception of three rings, the annihilator condition for finite commutative rings can be relaxed to a weaker criterion. This principle will be discussed, along with the three exceptional rings. (Received September 15, 2008)

1046-13-1238 **Warren Wm. McGovern*** (warrenb@bgnet.bgsu.edu), Department of Mathematics and Statistics, Bowling Green State University, Bowling Green, OH 43402. *Prufer domains with Clifford class semigroup.*

Bazzoni's Conjecture (from 1996) states that the Prufer domain R has finite character if and only if R has the property that an ideal of R is finitely generated if and only if it is locally principal if and only if the class semigroup of R is a Clifford semigroup. We will give a quick sketch proving the conjecture in the affirmative. (Received September 15, 2008)

1046-13-1255 **Benjamin R Lynch*** (lynch1@math.utk.edu), Department of Mathematics, University of Tennessee, Knoxville, TN 37996-1300. *Elasticity of Krull Domains with Infinite Class Groups.* Preliminary report.

One method for studying factorization properties of a Krull domain is to study the distribution of the height-one prime ideals in its divisor class group. In this talk, we will focus on infinite divisor class groups and will present results calculating the elasticity for different distributions of height-one primes. We will extend earlier results for $\mathbb{Z}$ to $\mathbb{Z} \oplus \mathbb{Z}$ and discuss the groups $\mathbb{Q}$ and $\mathbb{Z}(p^\infty)$. (Received September 15, 2008)

1046-13-1266 **Ryan E. Clark*** (rclark@math.utk.edu), Department of Mathematics, University of Tennessee, Knoxville, TN 37996-1300. *Generalized Boolean rings, idealizations, and zero-divisor graphs.* Preliminary report.

In this talk, we investigate the zero-divisor graph of a certain generalization of Boolean ring, the n-Boolean ring for $n \geq 2$. We will give examples and several results to describe the zero-divisor graphs of these rings. (Received September 15, 2008)

1046-13-1291 **Sarah Glaz*** (glaz@math.uconn.edu), Department of Mathematics, University of Connecticut, Storrs, CT 06269. *Gaussian Properties of Group Rings.* Preliminary report.

Let R be a commutative ring, and let f be a polynomial with coefficients in R. Denote by $c(f)$, the content of f, the ideal of R generated by the coefficients of f. A ring R is called a Gaussian ring if $c(f)c(g) = c(fg)$ for any two polynomials f and g with coefficients in R. Gaussian rings were defined by Tsang in 1965, and became an active topic of investigation due to their connection to Kaplansky's conjecture, which was solved between 1997 and 2005. The focus of these investigations lied in the comparison between the Gaussian property and several related ring theoretic and homological properties. Specifically the properties under consideration are: 1. R is a semihereditary ring. 2. $w.dimR$ is less or equal to 1. 3. R is an arithmetical ring. 4. R is a Gaussian ring. 5. R is locally a Prufer ring. 6. R is a Prufer ring. This talk will discuss the behavior of the six Gaussian-like properties in commutative group rings. In particular, we will consider several results and counterexamples, obtained by the speaker, to questions of ascent and descent of these properties between the ring R and the group ring RG, for an abelian group G. (Received September 15, 2008)

1046-13-1308 **Evan Houston*** (eghousto@uncc.edu), Dept. of Mathematics and Statistics, UNC Charlotte, Charlotte, NC 28223, and **Abdeslam Mimouni** (amimouni@kfupm.edu.sa), Dept of Mathematical Sciences, P.O. Box 5046, King Fahd University of Petroleum & Minerals, Khahran, 31261, Saudi Arabia. *On the t-spectrum of a Noetherian domain.* Preliminary report.

We study the t-spectrum of a Noetherian domain. (For a Noetherian domain a prime ideal is a t-ideal $\Leftrightarrow$ it is divisorial $\Leftrightarrow$ it is an associated prime of a principal ideal.) We prove that there are Noetherian domains of arbitrary t-dimension (including ∞) and that every finite poset with minimum element occurs as a saturated subset of the t-spectrum of a Noetherian domain. A corollary of this latter result is that any finite amount of non-catenary behavior can occur in the t-spectrum of a Noetherian domain. Pullbacks play a vital role in our constructions. (Received September 15, 2008)

1046-13-1319 **Meri T Florence*** (meri@uta.edu), 3821 Wharton Drive, Fort Worth, TX 76133. *Uniqueness of Minimal Acyclic Complexes.* Preliminary report.

In this talk we discuss conditions for uniqueness among minimal acyclic complexes of finitely generated free modules over a commutative local ring. Although uniqueness is known to hold for totally acyclic complexes, the question has been asked whether two minimal acyclic complexes in general can be isomorphic to the left and non-isomorphic to the right. We answer the question for certain cases, including periodic complexes, sesqui-acyclic complexes, and specific rings with radical cubed zero. (Received September 15, 2008)

1046-13-1327 **Mowaffaq Hajja*** (mowhajja@yahoo.com), Mathematics Department, Yarmouk University, Irbid, Jordan. *Negligibility of automorphisms of polynomial rings and other mathematical structures.* Preliminary report.

Let R_1, R_2 be polynomial rings over a field k, and let s_1, s_2 be k-automorphisms of R_1, R_2, respectively. Let I be the identity automorphism of R_2. We say that s_2 is negligible with respect to s_1 if $s_1 \otimes_k s_2$ is conjugate to $s_1 \otimes_k I$ in the group of k-automorphisms of $R_1 \otimes_k R_2$. Negligibility can be similarly defined if R_1, R_2 are purely transcendental field extensions of k. It can also be defined for automorphisms of vector spaces and automorphisms of free abelian groups.

In this talk, I shall present several instances of pairs s_1, s_2 of automorphisms for which s_2 is negligible with respect to s_1. (Received September 15, 2008)

1046-13-1332 **S. B. Mulay*** (mulay@math.utk.edu), Dept. of mathematics, University of Tennessee, Knoxville, TN 37996. *Special sequences for local domains.* Preliminary report.

The notion of a special sequence for a local domain whose associated graded ring is a finitely generated domian over a finite field will be presented along with some recent existence results about such sequences. (Received September 15, 2008)

1046-13-1344 **Muhammad Zafrullah*** (mzafrullah@usa.net), Department of Mathematics, Idaho State University, Pocatello, ID 83209. *Splitting sets and weakly Matlis domains.* Preliminary report.

Call an integral domain D a weakly Matlis domain if D is of finite t-character and if no two (distinct) maximal t-ideals of D contain a nonzero prime (t-)ideal. Recently Gabelli, Houston and Picozza, in [w-Divisoriality in polynomial rings, to appear in Comm. Algebra], have studied polynomial rings over weakly Matlis domains and have shown that in some cases a polynomial ring over a weakly Matlis domain may not be weakly Matlis. The purpose of this talk is to indicate the use of splitting sets and t-splitting sets in the study of polynomial rings over weakly Matlis domains. We show for instance that if $K \subseteq L$ is an extension of fields and X an indeterminate over L then the polynomial ring over $K + XL[X]$ is a weakly Matlis domain. (Received September 15, 2008)

1046-13-1345 **M. Axtell*** (maxtell@stthomas.edu), OSS 201, 2115 Summit Ave, St. Paul, MN 55105, and **J. Stickles** (jstickles@millikin.edu), 1184 West Main Street, Decatur, IL 62522. *Cut Vertices and Zero-Divisor Graphs.* Preliminary report.

A cut vertex of a connected graph is a vertex whose removal would result in the graph becoming two or more connected components. We examine the presence of cut vertices in zero-divisor graphs of finite commutative rings and provide a partial classification of the rings in which they appear. (Received September 15, 2008)

1046-13-1375 **K Alan Loper*** (lopera@math.ohio-state.edu), Department of Mathematics, Ohio State University - Newark, 1179 University Drive, Newark, OH 43055, and **Francesca Tartarone**. *Compact metric spaces and Prufer domains of polynomials.* Preliminary report.

It is well known that the maximal ideals of Int(Z) containing a given prime p can be naturally indexed by the p-adic integers. Much use has been made of the correspondence between the ideal structure of Int(Z) and the metric space topology of the p-adic integers. In this talk we extend this correspondence between maximal spectra and compact metric spaces to include all Prufer domains which lie between Z[X] and Q[X]. (Received September 17, 2008)

1046-13-1493 **Rachelle Renee Bouchat*** (rachelle.bouchat@sru.edu), Slippery Rock University, 1 Morrow Way, 003 Patterson Hall, Slippery Rock, PA 16057. *Square-free Monomial Ideals Associated to Ferrers Graphs.*

Each partition $\lambda = (\lambda_1, \lambda_2, \ldots, \lambda_n)$ determines a Ferrers graph, which is a class of bipartite graphs. In 2007, Corso and Nagel studied several characteristics of the toric rings of Ferrers graphs via Gorenstein liaison theory. We now consider several classes of square-free monomial ideals that arise as initial ideals of these toric ideals. Specifically, we will examine the reverse lexicographic term order and a modification of this term order using both basic double linkage from liaison theory and S-pairs from elementary Gröbner basis theory to generate and study these initial ideals. In particular, we will use these initial ideals to show that the toric rings of Ferrers graphs are level when certain restrictions are placed on the defining partition of the Ferrers graph. (Received September 15, 2008)

1046-13-1502 **Bernd Sturmfels** and **Josephine Yu*** (jyu@math.mit.edu), Department of Mathematics, MIT, 2-348, Cambridge, MA 02139. *Tropical Implicitization and Mixed Fiber Polytopes.*

We apply tropical geometry to study the image of a map defined by Laurent polynomials with generic coefficients. If this image is a hypersurface then our approach gives a construction of the Newton polytope of its defining equation. This construction can be used to compute mixed fiber polytopes, including secondary polytopes. (Received September 15, 2008)

1046-13-1557 **Lance Bryant*** (lbryant@math.purdue.edu), Mathematical Sciences Building, 150 North University Street, West Lafayette, IN 47907. *Goto Numbers in a Numerical Semigroup Ring.*

Let (R, m) be a Cohen-Macaulay local ring with dimension d, Q a parameter ideal of R with integral closure $\bar{Q}$, and $I_k = Q : m^k$. For the case $d \geq 2$, some general results concerning when $I_k \subset \bar{Q}$ are known. However, the one-dimensional case is rather different and more complicated to control. This talk is concerned with when $I_k \subset \bar{Q}$ in a numerical semigroup ring. This serves as a starting point for studying the $d = 1$ case. (Received September 16, 2008)

1046-13-1636 **Byung Gyun Kang*** (bgkang@postech.ac.kr), Department of Mathematics, Pohang, 790-784, South Korea, and **Phan Thanh Toan**. *Krull-dimension of a power series ring over a nonSFT-domain.*

Let D be a nonSFT-domain. We study a couple of cases when the Krull-dim $D[[X]]$ is uncountable. (Received September 16, 2008)

1046-13-1810 **Mohammed S Tesemma*** (mtesemma@spelman.edu), Spelman College, 350 Spelman Lane, SW, Box. 376, Atlanta, GA 30314. *Initial algebra of multiplicative invariants.*

Let's consider the Laurent polynomial ring $k[X^{\pm 1}] := k[x_1^{\pm 1}, \ldots, x_n^{\pm 1}]$, over a base fileld k. Let $G \leq GL_n(\mathbb{Z})$ act "*multiplicatively*" on $k[X^{\pm 1}]$. We characterize the cardinality of distinct initial algebras of the invariant ring $k[X^{\pm 1}]^G$ over all possible monomial orders on $k[X^{\pm 1}]$. (Received September 16, 2008)

1046-13-1829 **Kristen A Beck*** (kbeck@uta.edu), Department of Mathematics, The University of Texas at Arlington, P.O. Box 19408, Arlington, TX 76019. *Existence of Totally Reflexive Modules.* Preliminary report.

Totally reflexive modules are important to the study of maximal Cohen-Macaulay modules, complete resolutions, and subsequent complete homology and cohomology theories. A basic question is to consider which types of rings admit non-trivial totally reflexive modules. The premier class of rings which do so is the class of Gorenstein local rings, over which every maximal Cohen-Macaulay module is totally reflexive. In this talk we will define a class of non-Gorenstein local rings which admit non-trivial totally reflexive modules. (Received September 16, 2008)

1046-13-1914 **Michael A Freeze***, Department of Mathematics and Statistics, UNC Wilmington, 601 South College Road, Wilmington, NC 28403. *Zero-sum Sequence Designs.* Preliminary report.

Let $F(G)$ denote the free abelian monoid with basis given by the elements of a finite abelian group G. The block monoid over G has as elements the members $S = g_1 \cdots g_t$ of $F(G)$ for which $g_1 + \cdots + g_t = 0$ in G. These members S are called zero-sum sequences in G. We consider the construction of zero-sum sequences in G having regularity conditions on the proper, nonempty zero-sum subsequences. (Received September 16, 2008)

14 ► Algebraic geometry

1046-14-100 **Alexey Ovchinnikov*** (aiovchin@math.uic.edu), University of Illinois at Chicago, Department of Mathematics, Statistics, and Computer Science, Chicago, IL 60607. *Differential Tannakian categories.*

We define a differential Tannakian category and show that under a natural assumption it has a fiber functor. If in addition this category is neutral, that is, the target category for the fiber functor are finite dimensional vector spaces over the base field, then it is equivalent to the category of representations of a (pro-)linear differential algebraic group. Our treatment of the problem is via differential Hopf algebras and Deligne's fiber functor construction for the usual Tannakian categories. (Received July 22, 2008)

1046-14-169 **Elizabeth A. Sell*** (liz.sell@millersville.edu), Department of Mathematics, Millersville University, P.O. Box 1002, Millersville, PA 17551-0302. *On splice quotients of the form $\{z^n = f(x, y)\}$.*

The splice quotients, defined by W.D. Neumann and J. Wahl, are an interesting class of normal surface singularities with rational homology sphere links. The universal abelian cover of a splice quotient is a complete intersection surface singularity of a certain type, referred to as splice type. In general, it is difficult to determine whether or not a singularity is analytically isomorphic to a splice quotient, although there are certain necessary topological conditions. Let $\{z^n = f(x, y)\}$ define a surface $X_{f,n}$ with an isolated singularity at the origin in $\mathbb{C}^3$. We show that for irreducible f, if $(X_{f,n}, 0)$ satisfies the necessary topological conditions, then there exists a splice quotient of the form $(X_{g,n}, 0)$, where the plane curve singularity defined by $g = 0$ has the same topological type as the one defined by $f = 0$. We also present an example of an $(X_{f,n}, 0)$ that is not a splice quotient, but for which the universal abelian cover is a complete intersection of splice type together with a non-diagonal action of the discriminant group. (Received August 11, 2008)

1046-14-199 **Andrew S Obus*** (obusa@math.upenn.edu), 4203 Pine Street, Philadelphia, PA 19104. *Fields of moduli of three point covers.*

Abstract: In 1989, S. Beckmann showed that the field of moduli M of a 3-point G-Galois cover of the Riemann sphere is unramified at p if p does not divide the order of G. In 2003, S. Wewers showed that if p exactly divides the order of G, then p is at most tamely ramified in M. We ask whether the nth higher ramification group for the upper numbering at p of $\mathrm{Gal}(M/\mathbb{Q})$ vanishes, provided that G has a cyclic p-sylow subgroup of order p^n. We give a positive answer in the case that G does not have a simple composition factor with order divisible by p^n. (Received August 18, 2008)

1046-14-232 **Kathleen M Iwancio*** (kmiwanci@ncsu.edu), Department of Mathematics, 255 Harrelson Hall, Campus Box 8205, Raleigh, NC 27695. *Noise Tolerant Planar Curve Matching Using Invariants.*

Curve matching has a variety of applications in computer image processing and image recognition. This poster presents an investigation of a new noise tolerant method based on integral invariants. Applications to automated puzzle solving are considered. (Received August 21, 2008)

1046-14-247 **Ted Chinburg*** (ted@math.upenn.edu), Dept. of Mathematics, University of Pennsylvania, Philadelphia, PA 19104-6395, **Frauke M. Bleher** (fbleher@math.uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 522421419, and **Peter Symonds**, School of Mathematics, University of Manchester, Oxford Road, Manchester, M13 9PL, England. *Katz Gabber covers of curves with extra automorphisms.* Preliminary report.

A finite group G acting faithfully on a smooth projective curve X over a perfect field k defines a Katz-Gabber G-cover $f : X \to Y = X/G$ if Y is isomorphic over P_k^1, f is unramified outside of two points $\{0, \infty\}$ of Y, f is totally ramified over ∞ and f is at most tamely ramified over 0. Clearly G embeds into the automorphism group $\mathrm{Aut}_k(X)$ of X over k. This talk will report on results concerning the case in which $\mathrm{Aut}_k(X)$ is larger than G. This has applications to finding explicit formulas for automorphisms of $k((t))$ over k. (Received August 22, 2008)

1046-14-275 **Rakinawasan Sanjeewa*** (rsanjeew@oakland.edu), Oakland University, Department Of Mathematics and Statistics, Rochester, MI 48309, and **Tanush Shaska**. *Automorphism groups of cyclic curves defined over finite fields of any characteristics.*

We will discuss automorphism groups of algebraic cyclic curves defined over an algebraically closed field of any characteristic $p \neq 2$ and for any genus $g \geq 2$. We will give the list of all groups G of genus $g < 10$. For each g and G we will provide an equation for the corresponding curve. (Received August 25, 2008)

1046-14-312 **Ursula A Whitcher*** (ursula@math.washington.edu). *K3 Surfaces and Modular Parametrizations.*

The Griffiths-Dwork technique provides an algorithm for computing Picard-Fuchs equations for families of hypersurfaces in projective space. We use the Griffiths-Dwork technique to compute the Picard-Fuchs equations of a canonical family of lattice-polarized K3 surfaces, and relate the Picard-Fuchs equations to isogeny of elliptic curves.

This presentation describes joint work with A. Clingher, C.F. Doran, and J. Lewis. (Received August 25, 2008)

1046-14-315 **Ashraf A Ibrahim*** (aibrahim@math.tamu.edu), 401 Lincoln Ave. apt 32, College Station, TX 77840. *p-adic Descartes' Bounds.*

Descartes' rule of signs implies that any polynomial with real coefficients and exactly $k + 1$ monomial terms has at most $2k$ nonzero real roots. We discuss an analogue of this result over the p-adic fields, and an extension to systems of equations. In the multivariate case, we will talk about some recent results on estimating the exact number of geometrically isolated roots. Connections with computational complexity will also be discussed. (Received September 02, 2008)

1046-14-332 **Luis D. Garcia-Puente*** (lgarcia@shsu.edu), Department of Mathematics and Statistics, Sam Houston State University, Huntsville, TX 77341-2206, and **Frank Sottile** (sottile@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843-3368. *Geometrical aspects of control points for toric patches.* Preliminary report.

The control points and weights of a Bézier patch in geometric modeling provide an intuitive means to control the shape of the patch. Through de Castlejau's algorithm, the control points enable the computation of the patch. Finer aspects of the patch, particularly continuity and smoothness along the boundary between two patches are also determined by the control points. Global properties, such as the location of a patch in space, are also governed by the control points.

We use methods from toric geometry to explain how some further global properties of a patch are governed by the control points. We define the control surface, which is an analog of the control polygon of curves. This is a piecewise linear triangulated surface whose vertices are the control points. We show that regular control surfaces are the limits of patches as the weights undergo a toric deformation corresponding to the underlying regular triangulation. This gives a precise meaning to the notion that the shape of the control net governs the shape of the patch.

A second global property that we investigate is self-intersection. We give a simple condition on a set of control points which implies that the resulting patch is injective, for any choice of weights. (Received August 26, 2008)

1046-14-405 **Milagros Izquierdo*** (miizq@mai.liu.se), Matematiska institutionen, Linköpings universitet, 581 83 Linköping, Sweden, and **Antonio F. Costa**. *On the maximal order of an automorphism of a trigonal Riemann surface.*

A closed Riemann surface X which is a 3-sheeted covering of the Riemann sphere $f : X \to \widehat{\mathbb{C}}$ is called trigonal and the covering f is called a trigonal morphism. If f is a cyclic covering, then X is called cyclic trigonal. Otherwise X is called a generic trigonal surface. Let s be a singular value of f. If f is cyclic, then s is an order 3 singular value. If f is non-cyclic, then s is either a singular value of order three or a simple singular value. If all the singular values of f are simple we say that f is a simple covering. Simple coverings play an important role, for instance in the study of the moduli space. It is well known that the maximal order of an automorphism of a Riemann surface of genus g is $4g + 2$. We study the maximal order of an automorphism of a trigonal Riemann surface. We find that the order of an automorphism of a cyclic trigonal Riemann surface of genus g, $g \geq 5$, is at most $3g + 3$ while the order of an automorphism of a generic trigonal surface of genus g, $g \geq 5$, is at most $2g + 1$. Finally the obtain that the order of an automorphism of a trigonal surface with simple morphism is at most $g + 1$. We show that the bounds above are sharp for infinite families of curves. (Received September 01, 2008)

1046-14-429 **Reinier Broker*** (reinierb@microsoft.com), One Microsoft Way, MSR 99/2943, Redmond, WA 98052, and **Kristin Lauter**. *Explicit models for Siegel modular varieties.*

Modular polynomials are explicit models for the modular curves $Y_0(N)$ parametrizing elliptic curves together with a cyclic N-isogeny. These polynomials are used in many algorithms involving elliptic curves. In this talk we generalize this concept to the 2-dimensional case. We explain the theory surrounding Siegel modular varieties parametrizing N-isogenous 2-dimensional abelian varieties with level 3-structure. Furthermore, we describe a method to compute explicit models for these varieties and illustrate their use for explicit CM-theory. (Received September 02, 2008)

1046-14-433 **Robert Guralnick** and **Michael Zieve*** (zieve@math.rutgers.edu), Department of Mathematics, Rutgers University, 110 Frelinghuysen Road, Piscataway, NJ 08854. *Minimal-genus G-actions.* Preliminary report.

Let G be a finite group, and let p be either 0 or a prime number. Let $f(G, p)$ be the least integer $g > 1$ for which G acts on a genus-g curve over an algebraically closed field of characteristic p. I will discuss properties of $f(G, p)$, with particular emphasis on the uniformity of f as a function of G. I will also discuss the analogous problem for group actions on ordinary curves. (Received September 02, 2008)

1046-14-441 **Steven Bradlow**, **Oscar Garcia-Prada** and **Peter Gothen*** (pbgothen@fc.up.pt). *Deformations of maximal representations in the real symplectic group.* Preliminary report.

We answer the following question: When can a maximal $\mathrm{Sp}(4, \mathbf{R})$-representation of a surface group be deformed to a representation which factors through a proper reductive subgroup of $\mathrm{Sp}(4, \mathbf{R})$? (Received September 03, 2008)

1046-14-515 **Justin D Mazur*** (jdmazur@indiana.edu), 2001 Lingelbach Ln Apt 240, Bloomington, IN 47408. *Motivic Zeta-Functions for Curves with Group Actions.*

If C is a curve of genus g, the motivic zeta-function for C is a formal power series $\sum[Sym^n C]t^n$ with coefficients in the Grothendieck ring for varieties. Kapranov proved a generalized Weil's first conjecture for curves by proving the rationality of motivic zeta-functions for curves.

Now consider a variety, X, with an algebraic group, G, acting on it. In this paper, we will define the Grothendieck ring and motivic zeta-functions for varieties with G-actions. It turns out that convenient properties, like the fact that a fiber bundle can be written as a product in the Grothendieck ring, are no longer true except in special situations. This makes investigating the rationality of the motivic zeta-functions for curves with G-actions more difficult than in the classical problem. Despite this, the main goal of this paper is to prove the rationality of motivic zeta-functions for curves with finite abelian group actions. (Received September 05, 2008)

1046-14-519 **Aaron D Wootton*** (wootton@up.edu), 5000 N WILLAMETTE BLVD, Portland, OR 97203, and **J W Anderson**, School of Mathematics, Highfield, Southampton, SO17 1BJ, England. *Bounding the Number of Group Actions on a Surface of Fixed Genus.* Preliminary report.

Let S be closed oriented surface of genus σ and let N_σ be the number of distinct topological finite non-trivial group actions on S. For general σ, it is easy to determine a bound for N_σ, but such a bound is usually a gross over approximation. We consider the problem of refining such a bound. (Received September 05, 2008)

1046-14-520 **Anton Leykin*** (leykin@math.uic.edu). *Numerical primary decomposition.*
We establish a new approach to discover embedded components of an ideal in a polynomial ring. This not only leads to a new symbolic technique for computing primary decomposition, but also makes this problem accessible to hybrid symbolic-numerical techniques such as numerical homotopy continuation.

A collection of numerical data called *numerical primary decomposition* provides a full description of the complex variety defined by the given ideal. In particular, it serves as an alternative to Gröbner bases for solving the ideal membership problem. (Received September 05, 2008)

1046-14-524 **David Eisenbud*** (de@msri.org), Dept of Math, UCB, Berkeley, CA 94720, and **Bernd Ulrich**. *Assymptotic Regularity: Are we almost at infinity yet?* Preliminary report.
Suppose $I \subset S = k[x_0, \cdots, x_n]$ is a homogeneous ideal. A surprising theorem of Cutkosky-Herzog-Trung, Kodiyalam, and Trung-Wang asserts that for $t \gg 0$ the Castelnuovo-Mumford regularity of I^t is a linear function of t, say $dt + e$. The invariant d is relatively easy to identify, and in recent work Harris and I showed that, in a leading special case, the invariant e is connected with the regularities of fibers of a related morphism of varieties. That left—in every case—the question, "How large does t have to be?" I'll explain the background, and discuss a recent result from joint work with Bernd Ulrich that gives a reasonably sharp bound in the special case I treated with Harris. The work leaves open some fundamental questions about Rees algebras, and I'll discuss these as well. (Received September 06, 2008)

1046-14-535 **Jason P. Schmurr*** (schmurr@math.oregonstate.edu). *Translation Covers Among Triangular Billiards Surfaces.* Preliminary report.
We identify all translation covers among triangular billiards surfaces. Our main tools are the J-invariant of Kenyon and Smillie and a property of triangular billiards surfaces, which we call fingerprint type, that is invariant under balanced translation covers. (Received September 07, 2008)

1046-14-578 **Frank Sottile*** (sottile@math.tamu.edu), Department of Mathematics, Mailstop 3368, Texas A&M University, College Station, TX 77840-3368. *Experimentation at the frontier of reality in Schubert calculus.* Preliminary report.
The story of the deeply surprising proof and consequences of the recent theorem of Mukhin, Tarasov, and Varchenko (née the Shapiro Conjecture) will be the subject of an address in this year's AMS Current Events Bulletin. The interest in that conjecture was due in no small part to massive computation evidence that was amassed in its study, as the conjecture was originally considered too strong to possibly be true.

This talk will be concerned with the gathering of evidence for some extensions of the Shapiro conjecture. In particular, I will explain how our research team at Texas A&M University is organizing and controlling a computational experiment involving hundreds of computers and hundreds of Gigahertz-years of computation in the pursuit of evidence for one generalization which we call the secant conjecture. (Received September 08, 2008)

1046-14-633 **Yuri Lebedev*** (ylebedev@math.fsu.edu), 5670 Emma Ln, Tallahassee, FL 32317, and **Mika Seppala**. *OpenMath Library for Computing on Riemann Surfaces.*
This paper reviews computational methods that will act as a tool in the research of Riemann surfaces, algebraic curves and Jacobian varieties. Since the categories of algebraic curves, Jacobian varieties and Riemann surfaces are equivalent we would like to examine this equivalence from a computational point of view. If a Riemann surface is given, we want to compute an equation representing it as a plane algebraic curve, and also to calculate a period matrix for it. On the other hand, we would like to be able to compute the uniformization for a given algebraic plane curve, or a Riemann surface corresponding to a given Jacobian variety. Computer program RieSurGen is introduced to accomplish this task that also offers a convenient way of defining Mobius transformations and Riemann surfaces for computations using quaternions and implements OpenMath as its communication protocol. OpenMath is discussed as an extensible standard for representing the semantics of mathematical objects. Finally, OpenMath's Content Dictionary for computing on Riemann surfaces is proposed. (Received September 09, 2008)

1046-14-679 **Frank Sottile*** (sottile@math.tamu.edu), Department of Mathematics, Texas A&M University, Mail stop 3368, College Station, TX 77843. *Frontiers of reality in Schubert calculus.*
The Shapiro conjecture for Grassmannians (now a Theorem of Mukhin, Tarasov, and Varchenko) asserts that all (a priori complex-number) solutions to certain geometric problems from the Schubert calculus are actually real. Their proof is quite remarkable, using ideas from integrable systems and representation theory. This result has been used by Purbhoo to show that some basic combinatorial algorithms arise from geometry. Despite

these advances, the full Shapiro conjecture remains open with several interesting and not quite understood generalizations that are likely true.

This talk will introduce the Shapiro conjecture for Grassmannians and its links to subjects from combinatorics to complex analysis to control theory and then give an idea of its proofs and consequences, and its extensions.
(Received September 15, 2008)

1046-14-695 **Nejme Gjika*** (npjero@univlora.edu.al), Department of Mathematics, University of Vlora, Vlora, Albania, and **Miftar Ramosaco** (ramosaco@univlora.edu.al), Department of Mathematics, University of Vlora, Albania. *Degree even coverings of elliptic curves by genus 2 curves.*

A genus 2 curve C has an elliptic subcover if there exists a degree n maximal covering $\psi : C \to E$ to an elliptic curve E. Degree n elliptic subcovers occur in pairs (E, E'). The Jacobian J_C of C is isogenous of degree n^2 to the product $E \times E'$. We say that J_C is (n, n)-split. The locus of C, denoted by $\mathcal{L}_n$, is an algebraic subvariety of the moduli space $\mathcal{M}_2$.

We give a brief description of the spaces $\mathcal{L}_n$ for a general n and then focus on small n. We describe some of the computational details how to compute explicitly the space $\mathcal{L}_n$. Furthermore, we explicitly describe the relation between the elliptic subcovers E and E'. We have implemented most of these relations in computer programs which check easily whether a genus 2 curve has $(2, 2)$ or $(3, 3)$ split Jacobian. In each case the elliptic subcovers can be explicitly computed. (Received September 10, 2008)

1046-14-749 **Sean Lawton*** (slawton@math.ist.utl.pt), University of Maryland, Department of Mathematics, College Park, MD 20742, and **Carlos Florentino** (cfloren@math.ist.utl.pt), Lisbon, Portugal. *The topology of the moduli of free group representations.*

Let G be a complex affine reductive group and let K be a maximal compact subgroup. We have recently proved that the moduli space of representations $\mathrm{Hom}(F_r, G)/\!\!/G$ deformation retracts to the quotient space $\mathrm{Hom}(F_r, K)/K$ for any rank r free group F_r. If F_r is replaced by other finitely generated groups the theorem may be false, but not always. In this talk we discuss this theorem and some examples. (Received September 10, 2008)

1046-14-800 **Emma Previato*** (ep@bu.edu), Department of Mathematics and Statistics, Boston University, Boston, MA 02215-2411, and **T. Shaska**, Department of Mathematics and Statistics, Oakland University, Rochester, MI 48309. *Thetanulls of curves with automorphisms.*

The GAP BRAID routine due to K. Magaard, S. Shpectorov and H. Völklein (*Experiment. Math.* **12** (2003)) enabled the calculation of possible automorphism groups of curves, and polynomial equations for the corresponding curves, for small genus g (K. Magaard, T. Shaska, S. Shpectorov, H. Völklein, in *Communications in arithmetic fundamental groups* (2002)). We seek an equation in terms of thetanulls for each group, defining the locus $\mathcal{M}(g, G)$ of curves with automorphism group G in the moduli space, by expressing the equation of the curve by thetanulls (Thomae's formulas). In genus 2 (joint work with T. Shaska and S. Wijesiri, *Albanian J. Math.* **1** (2007)), the formulas in part are elegantly related to classical work by Jacobi and others, in part are pages long, calculated by computer using a characterization of the loci in terms of Igusa invariants (T. Shaska, *J. Symbolic Comput. 31* (2001)). In genus 3 (joint work with T. Shaska) we succeed in special cases and we give characterizations of a curve in $\mathcal{M}(3, G)$ in terms of Jacobian splitting (up to isogeny) and elements of finite order in the Jacobian. (Received September 11, 2008)

1046-14-857 **Rakinawasan Sanjeewa*** (rsanjeew@oakland.edu), Oakland University, Rochester, MI 48309. *Determining equations of families of cyclic curves.*

We will determine equations of cyclic curves for automorphism groups defined over algebraically closed field of characteristic $p \neq 2$. (Received September 12, 2008)

1046-14-889 **Harvey Cohn*** (hcohn@ccrwest.org), IDA Center for Communications Research, 4320 Westerra Court, San Diego, CA 92121. *Abelian Manifolds of arbitrary genus with Complex Multiplication.* Preliminary report.

Given a companion $(g \times g)$ matrix S for an irreducible monic equation with g real roots (listed in decreasing order) and integral matrices A, B commuting with S. Then we solve the matrix equation $W^2 - AW + B = 0$ (after diagonalizing by the Vandermondian). The diagonalized values of W are assumed totally complex with alternating signs for the imaginary surds. We also need a unimodular matrix U for which both U and US are symmetric. Then $Z = WU^{-1}$ is a Riemann Matrix ($Z = Z^t, \Im Z >> 0$) and the Abelian period matrix

$J = [E, Z]$ has the endomorphisms S, W, $(SJ = [S, ZS^t], WJ = [ZU, ZA^t - BU^{-1}])$. The case $g = 1$ is elliptic, and Humbert (1899) showed for $g = 2$ this is the most general case (not likely for $g > 2$). If the signs of the surds are chosen by group theory (not order) Z could be imaginary quadratic (but singular). (Received September 12, 2008)

1046-14-935 **James Price*** (jprice@math.purdue.edu), Department of Mathematics, Purdue University, 150 N. University Street, Lafayette, IN 47901. *Weighted Homogeneous Polynomials and the Jacobian in Two Variables.* Preliminary report.

In the early 1970s, Shreeram Abhyankar began giving lectures about his research on the Jacobian Conjecture. This talk will be concerned with the applications of this work to the Jacobian of two weighted homogeneous polynomials, i.e. $J(F, G) = F_X G_Y - F_Y G_X$. It turns out this equation in two variables can be reduced to an equation in just one variable. This leads to a better understanding of the relationship between F and G when the $J(F, G) = F^n$. This equation has been used by Abhyankar to show that a Jacobian pair has at most two weighted points at infinity when the weight is negative. Even though this statement should hold true for nonnegative weights, the same proof does not work because F and G have more freedom in $J(F, G) = F^n$ when the weight is nonnegative. It is hoped that a better understanding of $J(F, G) = F^n$ will give some insight into the Jacobian Conjecture. (Received September 12, 2008)

1046-14-991 **G Sujeeva Wijesiri*** (gswijesi@oakland.edu), Department of Mathematics & Statistics, Oakland University, Rochester, MI 48309. *Theta functions for small genus curves with automorphisms.*

Let $\mathcal{X}$ be an irreducible, smooth, projective curve of genus $g \geq 2$ defined over the complex field $\mathbb{C}$. Then there is a covering $\pi : \mathcal{X} \longrightarrow \mathbb{P}^1$, where $\mathbb{P}^1$ denotes the projective line. The problem of expressing branch points of the covering π in terms of the transcendentals (period matrix, thetanulls, e.g.) is classical. It goes back to Riemann, Jacobi, Picard and Rosenhein. Many mathematicians, including Picard and Thomae, have offered partial treatments for this problem. In this work, we address the problem for cyclic curves of genus 2, 3, and 4 and find relations among theta functions for curves with automorphisms. To characterize the locus of cyclic curves by analytic conditions on its Abelian coordinates, we use some classical formulas and symbolic computations, especially for genera 2 and 3. Fast genus 2 curve arithmetic in the Jacobian of the curve used in cryptography is based on inverting the moduli map for genus 2 curves and on some other relations on theta functions. We determine similar formulas and relations for genus 3 hyperelliptic curves. It is still to be determined whether our formulas for genus 3 curves can be used in cryptographic applications as in genus 2 curves. (Received September 13, 2008)

1046-14-996 **David Jensen*** (djensen@math.utexas.edu), 620 W 51st St, Apt #201, Austin, TX 78751. *Birational Geometry of the Moduli Space of Curves with Marked Points.*

A powerful tool in birational geometry is the cone of effective divisors of a variety. We examine this cone when the given variety is the moduli space of curves with one marked point, in some low genus cases. In particular, we identify divisors that lie on extremal rays of the cone - most notably, pointed analogues of Brill-Noether divisors that have been studied previously by Adam Logan. (Received September 13, 2008)

1046-14-1009 **Arsen Elkin*** (elkin@math.colostate.edu), 101 Weber Building, Department of Mathematics, Colorado State University, Fort Collins, CO 80523. *Cartier operator on Kummer covers of the projective line.*

We examine the action of the Cartier operator on the vector space of regular differential forms on cyclic covers of the projective line in positive characteristic p and implications of "periodicity" of this actions on invariants of p-torsion of the jacobian varieties of these curves. Specifically, we will give an upper bound on the a-number of these curves that improves upon a similar bound by Ricardo Re. (Received September 13, 2008)

1046-14-1062 **Emma Previato*** (ep@bu.edu), Department of Mathematics and Statistics, Boston University, Boston, MA 02215-2411, and **Shigeki Matsutani**. *Abelian formulas for cyclic curves.*

Generalized elliptic curves called $C_{a,b}$ curves, namely $f(x, y) = y^a + x^b + f_{a-1,b-1}(x, y)$ (a and b coprime positive integers and in $f_{a-1,b-1}(x, y)$, a monomial $x^r y^s$ satisfies $ar + bs < ab$), have emerged in areas as different as number theory and PDEs. Generalizing the genus-1 equation (Kiepert) for the nonzero points of period n, the determinant $\sigma(nz)/\sigma(z)^{n^2}$ of a matrix with entries derivatives of the $\wp$ function, we give a determinantal equation for a polynomial in (x, y) that vanishes at a point P of a $C_{a,b}$ curve iff the Abel image of nP belongs to the theta divisor Θ. We use addition theorems generalizing Klein-Baker's work on the higher-genus Weierstrass σ function (J.C. Eilbeck, V.Z. Enolski, S. Matsutani, Y. Ônishi and E. Previato, *Int. Math. Res. Not.* 2008).

For such curves with a specific group action we give more refined statements on the stratification of Θ. For a genus-3 curve that admits an automorphism of order 3 with quotient $\mathbb{P}^1$ we find formulas that generalize Jacobi's $\mathrm{sn}^2(z) + \mathrm{cn}^2(z) = 1$ (for a hyperelliptic curve, cf. S. Matusutani, *Surv. Math. Appl.* 2008). (Received September 14, 2008)

1046-14-1121 **Fabrizio Donzelli*** (fabrizio@math.miami.edu) and **Shulim Kaliman**. *Algebraic Density Property of Homogeneous Spaces.*

Let X be an affine algebraic variety with a transitive action of the algebraic automorphism group. Suppose that X is equipped with several non-degenerate fixed point free SL_2-actions satisfying some mild additional assumption. Then we show that the Lie algebra generated by completely integrable algebraic vector fields on X coincides with the set of all algebraic vector fields. (Received September 14, 2008)

1046-14-1124 **Hai-Jun Su*** (haijun@umbc.edu), 1000 Hilltop Circle, Department of Mechanical Engineering, University of Maryland, Baltimore County, Baltimore, MD 21250. *Computational Algebraic Geometry for Mechanism Synthesis.*

The mechanism synthesis problem begins with a task defined as a set of goal positions for the end-effector of the mechanism. Finding a mechanism which achieves the design goals becomes increasingly complicated as we move from planar mechanisms to mechanisms that move more generally in space. Algebraic equations can be developed to define the design outcomes. The equation set, and therefore the computational complexity, increases exponentially as the mechanism space becomes more general. In this work, we are interested in applying polynomial homotopy algorithms solving for multiple candidate mechanisms. Recently this work has been successfully extended to the synthesis of compliant mechanisms. Compliant mechanisms gain at least some mobility from the deflection of flexible members rather than from movable joints only. These mechanisms hold promise in areas of manipulation; actuator, measurement devices etc. and are well suited for micro fabrication (MEMS). In this talk, a systematic way is proposed to synthesize compliant mechanisms for a specified set of equilibrium positions. The synthesis equations are transformed into a polynomial form and solved by homotopy solvers. (Received September 14, 2008)

1046-14-1164 **Sabin Cautis*** (scautis@math.harvard.edu), 96 Fifeshire Rd. Apt 501, Toronto, Ontario M2L2X9, Canada. *Towards a geometric categorification of the coloured Reshetikhin-Turaev sl(m) knot invariants.*

To any tangle whose strands are decorated with a representation of sl(m) one can associate its Reshetikhin-Turaev (RT) invariant. In particular, given a knot K one obtains a polynomial knot invariant. Ideally, one would like to assign to K a complex whose (graded) Euler characteristic is the RT invariant of K. This has been done (in more than one way) when the representation is the standard representation of sl(m). We conjecture a way to do this for arbitrary wedge products of the standard representation. This involves studying coherent sheaves on certain flag like varieties and is related to work of Chuang-Rouquier and Khovanov-Lauda. (Received September 14, 2008)

1046-14-1179 **Yisha Peng*** (pengpche@gmail.com), Lantian 5-1077, ZJG Campus, Zhejiang University, Hangzhou, Zhejiang 310058, Peoples Rep of China. *A Linear Algebraic Proof of Demailly and Skoda's Theorem.*

Demailly and Skoda's theorem is very famous and important in algebraic geometry area. However, the traditional proof of this theorem requires highly advanced mathematical skills such as Fourier analysis. Also, some prior knowledge of Nakano Positive, Griffths Positive and vector bundle are required. In our paper, we translate this complicated algebraic geometry theorem into simple matrix language. We also transform the proof of this theorem into the proof of a hermitian matrix's positiveness. In the end, we give an elementary proof of this transformed one. In this way, even a freshman in college can understand this complicated theorem and the beautiful proof of it. (Received September 15, 2008)

1046-14-1239 **Mark E Huibregtse*** (mhuibreg@skidmore.edu), Dept. of Mathematics and Computer Science, Skidmore College, Saratoga Springs, NY 12866. *Some syzygies of the generators of the ideal of a border basis scheme.* Preliminary report.

Let K be an alg. closed field, $\mathrm{char}(K) = 0$. An $\mathcal{O}$-border basis scheme $\mathbb{B}_{\mathcal{O}}$ [Kreutzer and Robbiano, Deformations of Border Bases, Collect. Math. 59, no. 3 (2008)] parameterizes the ideals $I \subseteq K[x_1, \ldots, x_n]$ such that $K[\mathbf{x}]/I$ has K-basis the order ideal $\mathcal{O} = \{t_1, \ldots, t_\mu\}$. Any such I has (unique) generators of the form $g_j = b_j - \sum_{i=1}^{\mu} c_{ij} t_i$, $1 \le j \le \nu$, where $\{b_1, \ldots, b_\nu\} = (x_1\mathcal{O} \cup \cdots \cup x_n\mathcal{O}) \setminus \mathcal{O}$ is the border of $\mathcal{O}$. Viewing the c_{ij} as variables, one has that $\mathbb{B}_{\mathcal{O}} \subseteq \mathrm{Spec}(K[(c_{ij})])$ is cut out by the entries ρ_{pq}^{kl} of the basic commutators $\mathcal{A}_k\mathcal{A}_l - \mathcal{A}_l\mathcal{A}_k$ of the matrices representing multiplication by $x_k \ne x_l$ on $K[(c_{11}, \ldots, c_{\mu\nu})][x_1, \ldots, x_n]/(g_j)$. We construct syzygies of the ρ_{pq}^{kl}

by taking traces of products of the $\mathcal{A}_k$ and the basic commutators that reduce to commutators. The simplest examples are: $\mathrm{Tr}(\mathcal{A}_k\mathcal{A}_l - \mathcal{A}_l\mathcal{A}_k) = \sum_{i=1}^{n} \rho_{ii}^{kl} = 0$. (Received September 15, 2008)

1046-14-1272 **Dan Bates** and **Frank Sottile*** (sottile@math.tamu.edu), Department of Mathematics, Mailstop 3368, Texas A&M University, College Station, TX 77843. *Khovanskii-Rolle continuation for real solutions.* Preliminary report.

Continuation methods are numerical algorithms which find all solutions to a system of polynomials by numerically tracing curves. Well-known are homptopy methods, where the curves arise from degenerations of the system, connecting solutions to the original system to those for simpler systems.

With Dan Bates, we propose a different method which is based on Khovanskii's generalization of Rolle's theorem and the notion of Gale duality for polynomial systems. Unlike homotopy continuation, this algorithm only finds real-number solutions and its complexity depends only on the number of real solutions, and not on the algebraic degree of the equations.

In this talk, I will sketch the main ideas in this new algorithm and show how it works in an implementation that we have made which is restricted to Gale-dual systems in the plane. (Received September 15, 2008)

1046-14-1394 **Elisha Peterson*** (triathematician@gmail.com) and **Sean Lawton** (slawton@math.ist.utl.pt). *Trace Diagram Recurrences and Central Functions of SL(2,C)-Character Varieties.* Preliminary report.

The coordinate ring of $\mathrm{SL}(2,\mathbb{C})$-character varieties may be studied in terms of a basis of *central functions*. These functions are usually defined algebraically, but they can also be defined using the graphical calculus of trace diagrams. This diagrammatic approach is more useful for building intuition about the structure of the coordinate ring, and also simplifies computations. In this talk, we describe the central function basis and its diagrammatic depiction, and also show how a trace diagram recurrence formula gives rise to a generic algorithm for computing these functions. (Received September 16, 2008)

1046-14-1410 **Tristram C Bogart*** (tcbogart@gmail.com), Department of Mathematics and Statistics, Room 310, Jeffery Hall, Queen's University, Kingston, Ontario K7L 3N6, Canada. *A tropical approach to rational curves on general hypersurfaces in $\mathbb{P}^3$.*

In the 1980's, Herbert Clemens made a series of conjectures about the dimensions of spaces of rational curves on general complex hypersurfaces in projective space. The most general of these conjectures is that there are only finitely many rational curves of degree d on a general quintic threefold in $\mathbb{P}^4$. He proved that a general hypersurface of degree $2n-1$ in $\mathbb{P}^n$ contains no rational curves, a statement generalized and strengthened by Geng Xu and by Claire Voisin.

In ongoing joint work with Ethan Cotterill, we approach these questions via tropical geometry. Since tropicalization preserves inclusion, the tropical analogue of Clemens' theorem would imply the original theorem. Magnus Vigeland recently produced a family of tropical surfaces in $\mathbb{R}^3$ of degree d that contain no tropical lines when d is at least four. Our current result is that Vigeland's surfaces contain no tropical rational curves that are generic in a certain sense. (Received September 15, 2008)

1046-14-1435 **Sebastian Xambó-Descamps*** (sebastia.xambo@upc.edu), c. Pau Gargallo, 5, 08028 Barcelona, Spain. *WIT: A Structured and Comprehensive Package for Computations in Intersection Theory.*

Computations in intersection theory, in the sense of algebraic geometry, an in particular in enumerative geometry, are a wonderful target for testing the expressiveness and power of computational mathematics systems. In this talk the focus will be on how to structure a package of funtions that allows the user to express intersection theory computations in a very compact way, with a syntax that is very close to the mathematics involved, and in illustrating how it works in the case of a current (enumerative geometry) research problem by means of an implementation that can be freely accessed with any one of the familiar navigators. The tentative index will be:

- Basics on intersection theory
- Natural structuring of the functions required for computations
- Guidelines for implementations
- The wit system
- An example drawn from recent research
- Conclusions

(Received September 15, 2008)

1046-14-1451 **Dan Bates**, **Jon Hauenstein**, **Tim McCoy**, **Andrew Sommese** and **Christopher Peterson*** (peterson@math.colostate.edu). *Partial decomposition of radical ideals through numerical homotopy and lattice basis reduction.*

In this joint work we illustrate how one can (sometimes) use numerical methods to achieve a partial decomposition of a radical ideal. The main numerical tools are homotopy continuation methods combined with lattice basis reduction. The method is implemented via a Maple interface to the Bertini software package for numerical algebraic geometry. (Received September 15, 2008)

1046-14-1494 **Enver Ozdemir*** (enveroz@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 21227. *Group Operation on the Jacobian of Singular Hyperelliptic Curves.* Preliminary report.

Let H be a singular hyperelliptic curve over a field F. In this talk, we will describe the group operation on the Jacobian of H and possible applications to factorization of polynomials and cryptography. We will then present a geometric analogue of Shanks' Algorithm and new methods for square roots . (Received September 15, 2008)

1046-14-1522 **Yuri Zarhin*** (zarhin@math.psu.edu), Pennsylvania State University, Department of Mathematics, McAllister Building, University Park, PA 16802. *Prym varieties of trigonal curves.*

Using Galois Theory, we construct explicitly absolutely simple Prym varieties that are not isomorphic to jacobians of curves even if we ignore the polarizations. Our approach is based on author's papers arXiv:math/0610138[math.AG] and arXiv:math/0605028 [math.AG]. (Received September 15, 2008)

1046-14-1617 **Injun Song*** (megahopper@kaist.ac.kr), **Eu Kyum Kim** (kimeukyum@kaist.ac.kr) and **Hum Kum** (HunKim@kaist.ac.kr). *On 3-dimensional tiling.* Preliminary report.

In this paper, we studied about mathematical tiling, especially on simple tiling. A tiling of rectangle R is called simple if no connected set of two or more elements in tiling forms a rectangle strictly inside of R. We reviewed the simple tiling on 2-dimensions first. Then along with the theorems of those 2-dimensional simple tiling theorems, we applied them to 3-dimensions. We defined simple tiling in three dimensions, discovered the condition of the existence of simple tiling, and found out average volume of the elements in simple tilings. And we will introduce some results about simple tilings using only one type of tilings. (Received September 16, 2008)

1046-14-1705 **Frank Sottile*** (sottile@math.tamu.edu), Department of Mathematics, Texas A&M University, Mail stop 3368, College Station, TX 77843. *Experimentation at the frontier of reality in Schubert calculus.* Preliminary report.

The story of the deeply surprising proof and consequences of the recent theorem of Mukhin, Tarasov, and Varchenko (née the Shapiro Conjecture) will be the subject of an address in this year's AMS Current Events Bulletin. The interest in that conjecture was due in no small part to massive computational evidence that was amassed in its study, as the conjecture was originally considered too strong to possibly be true.

This talk will be concerned with the gathering of evidence for some extensions of the Shapiro conjecture. In particular, I will explain how our research team at Texas A&M University is organizing and controlling a computational experiment involving hundreds of computers and hundreds of Gigahertz-years of computation in the pursuit of evidence for one generalization which we call the secant conjecture. (Received September 16, 2008)

1046-14-1756 **Darren Glass** and **W. David Joyner*** (wdj@usna.edu), Mathematics Department, United States Naval Academy, Annapolis, MD 21402, and **Amy Ksir**. *Structure of Riemann-Roch G-modules for $y^m = x^p - x$ over $GF(p)$.*

Let X denote the curve $y^m = x^p - x$ over a field of characteristic p. It is known that the automorphism group G of X is an extension of $\mathbb{Z}/m\mathbb{Z}$ by $PGL(2,p)$. Let D be a G-invariant divisor on X. We compute explicitly the G-module structure of the Riemann-Roch space $L(D)$ (equivalently, on the linear system $|D|$). Examples using SAGE are given to illustrate both the computational nature of the results, and the applications to the theory of error-correcting codes. (Received September 16, 2008)

1046-14-1768 **Nathan Drake*** (ndrake@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634-0975. *On decoding multipoint algebraic geometry codes.*

Algebraic geometry codes (AG codes) have attracted a great deal of attention since their advent. AG codes are generalizations of the widely implemented Reed-Solomon codes, and the construction of AG codes yields a family of codes with parameters exceeding the Gilbert-Varshamov bound. An AG code is defined using divisors D and G on a curve X over a finite field. Such a code is called an m-point code if there are exactly m points in the support of the divisor G. A multipoint code is an m-point code with $m > 1$. The majority of the work on AG codes has focused on one-point codes, meaning that the divisor G is a multiple of a single rational point. However, at times, allowing G to be more general yields codes with better parameters than their one-point counterparts. Even so, most decoding algorithms are designed for the one-point case. In this talk we present a decoding algorithm for multipoint codes that utilizes list decoding in a supercode. (Received September 16, 2008)

1046-14-1873 **Yun Guan*** (guan@math.uic.edu), Department of Mathematics, Statistics, and Computer Science, 851 South Morgan (M/C 249), Chicago, IL 60607-7045, and **Jan Verschelde** (jan@math.uic.edu), Department of Mathematics, Statistics, and Computer Science, 851 South Morgan (M/C 249), Chicago, IL 60607-7045. *Solving Polynomial Systems on a Parallel Computer with PHCpack and PHClab.*

PHCpack is an open source software package for numerical algebraic geometry. It implements numerical algorithms for solving polynomial systems using homotopy continuation methods. Our MATLAB/Octave package PHClab provides a convenient interface to the functions of PHCpack. With the help of the MPI ToolBox (MPITB) for Octave, we solved a list of polynomial systems on our cluster computer. Another algorithm that runs on our cluster is the diagonal homotopy method for computing the intersection of two algebraic sets. This method is a key ingredient in the subsystem-by-subsystem solver of PHCpack. Our parallel implementation of this solver allows to find numerical representations of all the solution components of large systems more efficiently. Dynamic load balancing leads to an acceptable speedup. (Received September 16, 2008)

1046-14-1921 **Elisabetta Fortuna**, **Patrizia Gianni** and **Barry Trager*** (bmt@us.ibm.com), IBM TJ Watson Research Center, 1101 Kitchawan Road, Yorktown Heights, NY 10598. *Generators of the ideal of an algebraic space curve.*

We show that the ideal of any reduced algebraic curve in affine 3-space whose Jacobian matrix has rank at least 1 at every singular point of the curve can be generated by three polynomials and we give constructive procedures to compute such generators. This generalizes Abhyankar's result for smooth irreducible space curves. The algorithms we present are probabilistic with certificates of validity and operate in polynomial time. (Received September 16, 2008)

15 ► Linear and multilinear algebra; matrix theory

1046-15-85 **Lon H Mitchell***, Department of Mathematics, Virginia Commonwealth University, 1001 West Main Street, Richmond, VA 23284. *Chordal Supergraphs and Minimum Semidefinite Rank.*

For an undirected simple graph G, the minimum rank among all positive semidefinite matrices with graph G is called the minimum semidefinite rank (msr) of G. We show that the msr of a graph G is bounded below by the msr of certain chordal graphs containing G as a subgraph. This improves upon a previous lower bound for msr given by OS sets. (Received July 22, 2008)

1046-15-90 **Jennifer L. Wolfe*** (wolfe2jl@cmich.edu), **Rachael L. Tomasino**, **Eileen L. Radzwion** and **Sara P. Rimer**. *Frames: Surgeries, Dilation, and Robustness.* Preliminary report.

Frames are redundant sets of vectors, denoted $\{f_i\}_{i=1}^n$, in a Hilbert space $\mathcal{H}$. They are a nontrivial generalization of orthonormal bases, and share many nice properties with orthonormal bases. The added redundancy from additional vectors allows for reconstruction of lost data in data transfers. We have considered some of the properties of frames that make them most successful in data transfer, such as frame surgeries, dilation of frames into higher dimensions, and robustness of frames. In particular, due to the straightforward nature of tight and Parseval frames, they are a main focus of our studies. In this talk, we will present the necessary background material and some new results. (Received July 22, 2008)

1046-15-91 **Taiji Tsutsui*** (tsutsuit@my.hiram.edu), PO Box 1234, Hiram, OH 44234, and **Rachel Ellen Cranfill** (rachel_cranfill@hmc.edu). *The Minimum Semidefinite Rank of a Graph.*

A Hermitian matrix is a complex matrix that is equal to its conjugate transpose. Given an n by n Hermitian matrix A, we associate a graph G(A) whose vertex set is $\{1, \ldots, n\}$ and whose edge set consists of unordered pairs $\{i, j\}$ if and only if the (i, j)th entry of A is nonzero. The collection of Hermitian positive semidefinite matrices that share a common graph G is denoted P(G). Define the minimum semidefinite rank of G or msr(G) to be the minimum rank over all matrices in P(G). We provide a characterization of graphs G for which msr(G)=3 and some necessary conditions for when msr(G) is equal to ts(G) - 1, where ts(G) is defined to be the number of vertices in a maximum induced tree of G. (Received July 22, 2008)

1046-15-141 **Paul A Sundheim*** (paul.sundheim@uwc.edu), 1500 University Drive, University of Wisconsin, Waukesha, WI 53188. *An Associative Multiplication for Multidimensional Matrices.* Preliminary report.

An n-matrix of order m will be an $m \times m \times m \times \cdots \times m$ (n factors) multidimensional matrix. An associative multiplication for n-matrices of order m is defined and properties of the multiplication are discussed. If A_n is the collection of n-matrices of order m, then A_2 is the classical ring of square matrices of order m and the resulting system of rings is graded with A_{n-1} a subring of A_n. Furthermore, the $m = 2$ case contains an infinite system of commutative hypercomplex numbers. (Received August 05, 2008)

1046-15-200 **Wasin So*** (so@math.sjsu.edu), Department of Mathematics, San Jose State University, San Jose, CA 95192. *The skew spectrum of an oriented tree.* Preliminary report.

An oriented graph is a simple graph with an orientation, which assigns each edge a direction so that the resulting graph becomes a directed graph. With a labeling of its vertices, an oriented graph is associated with a skew symmetric matrix defined by $s_{ij} = 1$ and $s_{ji} = -1$ if (i, j) is an assigned direction of the edge $\{i, j\}$, otherwise $s_{ij} = s_{ji} = 0$. The skew spectrum of an oriented graph is defined as the spectrum of the associated skew symmetric matrix.

In this talk, we prove that the skew spectrum of an oriented tree is independent of its orientation. Indeed, the skew spectrum is determined by the spectrum of the underlying tree. (Received August 18, 2008)

1046-15-440 **Abdel Nasser El-Kassar*** (abdulnasser.kassar@lau.edu.lb), Mme Curie Street, P.O. Box 13-5053, Beirut, 1102-2801, Lebanon, and **Samer S. Habre** and **Yehia Awad**. *GCD and LCM Matrices on Factor Closed Sets Defined over Principal Ideal Domains.*

Let $S = \{x_1, x_2, ..., x_n\}$ be a set of n distinct positive integers and let $s_{ij} = (x_i, x_j)$ be the greatest common divisor of x_i and x_j. The matrix $[S] = (s_{ij})$ is called the greatest common divisor (GCD) matrix on S. The matrix $[[S]]$ having its i, j-entry as the least common multiple of x_i and x_j is called the least common multiple (LCM) matrix on S. A set S is said to be factor closed (FC) if it contains every divisor of x for any $x \in S$. Smith (1875) showed that the determinant of $[S]$ on a FC set S is the product $\prod_{i=1}^{n} \phi(x_i)$, where ϕ is Euler's totient phi-function. Moreover, he obtained a formula for the determinant of $[[S]]$ on a FC set. In 1989, Beslin and Ligh obtained a structure theorem for GCD matrices and generalized the Smith's determinant to factor closed sets.

Since then many results concerning GCD and LCM matrices have been published.

In this paper, we generalize the notions of GCD and LCM matrices to any principal ideal domain (PID). Many of the important results, such as structure theorems, converse of Smith's result, determinants of reciprocal GCD matrix, inverse GCD matrix, and LCM matrix, are extended to such domains. (Received September 03, 2008)

1046-15-541 **Charles Waters** (charles.waters@mnsu.edu), Department of Mathematics and Statistics, 273 Wissink Hall, Mankato, MN 56001, and **In-Jae Kim*** (in-jae.kim@mnsu.edu), Department of Mathematics and Statistics, 273 Wissink Hall, Mankato, MN 56001. *Low Rank Perturbations and Inertias of Full Symmetric Sign Patterns.*

For a given n by n complex (resp. real) matrix A, we use a rank-one (resp. rank-two) perturbation to alter exactly one eigenvalue (resp. exactly one pair of complex-conjugate eigenvalues) of A while keeping the others equal. We use this low-rank perturbation to derive inertias of a full symmetric sign pattern $\mathcal{A}$ from a known inertia (p, q, r) of $\mathcal{A}$ with $r \geq 1$. (Received September 07, 2008)

1046-15-568 **Pauline van den Driessche*** (pvdd@math.uvic.ca), Department of Mathematics and Statistics, University of Victoria, Victoria, BC V8W3R4, Canada. *Spectra of Matrices Applied to Dynamical Models of Infectious Disease.*

Compartmental models of infectious disease are frequently formulated as systems of ordinary differential equations. Matrices that appear in the analyses of equilibria of these systems often have known sign patterns. For example, they may be entrywise nonnegative or have the Z-sign pattern. Models appropriate for the spread of influenza illustrate how matrix analysis can be applied to determine the dynamical behavior of such systems. (Received September 08, 2008)

1046-15-628 **I.-J. Kim**, **D. D. Olesky**, **B. L. Shader**, **P. van den Driessche**, **H. van der Holst** and **K. N. Vander Meulen***, Department of Mathematics, Redeemer University College, 777 Garner Road, Ancaster, Ontario L9K 1J4, Canada. *Potentially Nilpotent Full Sign Patterns.*

Much work on sign patterns has focused on sparse sign patterns. This talk will consider full sign patterns: patterns with no zero entries. The refined inertia of a matrix pattern is defined and techniques are developed for constructing potentially nilpotent full sign patterns. Such patterns are spectrally arbitrary. These techniques can also be used to construct potentially nilpotent sign patterns that are not full, as well as potentially stable sign patterns. (Received September 09, 2008)

1046-15-671 **Leslie Hogben*** (LHogben@iastate.edu), Department of Mathematics, Carver Hall, Iowa State University, Ames, IA 50011. *Spectra of Matrix Patterns.*

This talk will survey basic results and applications of spectra of matrix patterns and will serve as an introduction to the special session on Spectra of Matrix Patterns and Applications to Dynamical Systems. (Received September 09, 2008)

1046-15-708 **Adam H Berliner*** (berliner@math.wisc.edu), Van Vleck Hall, 480 Lincoln Dr., Madison, WI 53706. *On m-convertible matrices.* Preliminary report.

If B is a $(0, 1, -1)$-matrix for which there is a nonzero term in the classical determinant expansion and each nonzero term has the same sign then B is called *sign-nonsingular* and $A = |B|$ is called *convertible*. These matrices have been studied extensively in the literature. In this talk we will explore properties of certain types of convertible matrices and the notion of m-convertibility. That is, when is it possible to write per(A) as the sum of determinants of signings of A in such a way that results in an algebraic identity? (Received September 10, 2008)

1046-15-766 **Orly Alter*** (orlyal@mail.utexas.edu), Department of Biomedical Engineering, 1 University Station, A4800, University of Texas at Austin, Austin, TX 78712. *Discovery of Principles of Nature from Mathematical Modeling of DNA Microarray Data: Computational Prediction and Experimental Verification.*

Future discovery and control in biology and medicine will come from the mathematical modeling of DNA microarray data. Such models were recently created using matrix computations, where the mathematical variables, patterns uncovered in the data, correlate with activities of cellular elements. The operations, such as data reconstruction in subspaces of selected patterns, simulate experimental observation of the correlations and possibly also causal coordination of these activities. The ability of these models to predict previously unknown biological as well as physical principles was also demonstrated [1]. I will describe the first comparative and integrative models that were created from DNA microarray data using tensor computations [2–4].

Pseudoinverse projection and a higher-order singular value decomposition models uncovered independently a genome-scale correlation between DNA replication and mRNA expression, which might be due to a previously unknown cellular mechanism of regulation. I will describe recent experimental results that verify this computationally predicted mechanism.

1. Alter, PNAS 103, 16063 (2006).
2. Alter & Golub, PNAS 102, 17559 (2005).
3. Omberg, Golub & Alter, PNAS 104, 18371 (2007).
4. Ponnapalli, Saunders, Golub & Alter, submitted. (Received September 13, 2008)

1046-15-1029 **Mahmud Akelbek** and **Steve Kirkland*** (kirkland@math.uregina.ca), Department of Mathematics and Statistics, University of Regina, Regina, SK S4S 0A2, Canada. *Eigenvalues and the scrambling index for stochastic matrices.*

A square, entrywise nonnegative matrix with every row sum equal to 1 is known as a *stochastic matrix*. Any stochastic matrix T has 1 as an eigenvalue of largest complex modulus, and the size of the second largest (in modulus) eigenvalue of T is of interest because it determines the asymptotic rate of convergence of the sequence of powers of T.

In this talk, we introduce the notion of the scrambling index of a directed graph, and discuss some of its properties. We then use the scrambling index of the directed graph of a stochastic matrix T in order to produce an attainable upper bound on the size of the second largest eigenvalue of T. (Received September 14, 2008)

1046-15-1268 **Shaun M Fallat*** (sfallat@math.uregina.ca), Department of Mathematics and Statistics, University of Regina, Regina, Sask. s4s0a2, Canada. *Minimum Rank of Various Matrix Patterns.* Preliminary report.

The intention of this talk is to survey the different existing notions of minimum rank (or maximum multiplicity) for many different matrix patterns, including: symmetric real and complex patterns, assymetric patterns, and signed patterns. (Received September 15, 2008)

1046-15-1339 **Judith J McDonald*** (jmcdonald@math.wsu.edu), Dept of Mathematics, Box 643113, Washington State University, Pullman, WA 99164-3113. *Spectral properties of nonnegative and eventually nonnegative matrices.*

During this talk we will look at spectral properties of nonnegative and eventually nonnegative matrices. In particular, we will discuss the relationship between the Jordan form of a nonnegative or eventually nonnegative matrix, and its combinatorial structure. (Received September 15, 2008)

1046-15-1342 **Elizabeth J Bodine*** (ebodine@math.wsu.edu), Department of Mathematics, Box 643113, Washington State University, Pullman, WA 99164-3113. *Spectrally arbitrary patterns 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 $p_A(x) = r(x)$. In this talk, we will investigate several zero-nonzero patterns over finite fields and show over which finite fields these patterns are spectrally arbitrary. We will explore the relationship between the number of nonzero entries of the matrix and the size and characteristic of the finite field in order to develop some necessary conditions and sufficient conditions for a pattern to be spectrally arbitrary. (Received September 15, 2008)

1046-15-1403 **Rana Mikkelson*** (ranam@iastate.edu), Department of Mathematics, 396 Carver Hall, Iowa State University, Ames, IA 50011. *Minimum Rank of Looped Graphs with Cut Vertices.*

If we associate a set of matrices over a field with a graph, such that the i, j entry of any matrix in the set is nonzero if and only if $\{i, j\}$ is an edge in the graph, then minimum rank is the minimum among the ranks of the matrices in the associated set. The Minimum Rank problem has been studied extensively for simple graphs and is solved for simple trees over any field. It is also known that the minimum rank of a simple graph with a cut vertex can be computed using a cut-vertex reduction, i.e. by breaking the graph up into pieces and calculating the minimum rank of each piece. We extend the cut vertex reduction to graphs that allow loops over any field with more than two elements and use it to prove that the minimum rank of a tree that allows loops over any field with more than two elements can be found using a known algorithm for computing minimum rank over the reals. (Received September 15, 2008)

1046-15-1404 **John R. Greene*** (jgreene@d.umn.edu), Department of Mathematics and Statistics, University of Minnesota Duluth, Duluth, MN 55812. *Traces of matrix products.* Preliminary report.

Given two noncommuting 2x2 matrices A and B, what can be said about traces of products of these two matrices? It is well known that AB and BA have the same trace. This easily generalizes to cyclic permutations. For example, AABB, BAAB, BBAA and ABBA all have the same trace. However, AABB and ABAB usually have different traces. We show that there is another symmetry: reversal. That is, AABBAB and BABBAA have the same trace even though they are not cyclic permutations of each other. We also address problems of the following type: Which is usually larger, tr(ABAB) or tr(AABB)? (Received September 15, 2008)

1046-15-1409 **Amy Ann Yielding*** (yielding@math.wsu.edu), PO Box 643113, Department of Mathematics, Washington State University, Pullman, WA 99164, and **Judith J McDonald**. *Complex spectrally arbitrary zero-nonzero patterns whose Jacobian is zero at every nilpotent realization.*

In this talk we will highlight interesting properties of complex spectrally arbitrary patterns. In particular, we will investigate complex spectrally arbitrary patterns whose Jacobian is zero at every nilpotent realization and complex spectrally arbitrary patterns whose corresponding graph does not contain a two-cycle. (Received September 15, 2008)

1046-15-1422 **Richard Brualdi**, **Louis Deaett**, **Luz DeAlba**, **Jason Grout*** (grout@iastate.edu), **In-Jae Kim**, **Steve Kirkland**, **Raphael Loewy**, **Judith McDonald**, **Pauline van den Driessche** and **Amy Yielding**. *Minimum rank of graph powers.* Preliminary report.

For a simple undirected graph G, let G^r, the rth graph power of G, be the graph with the same vertices as G and edges

$$\{(u,v) \mid \text{there exists a walk of length at most } r \text{ from } u \text{ to } v \text{ in } G\}.$$

The minimum rank of a simple undirected graph with n vertices is the minimum rank over all real symmetric $n \times n$ matrices with nonzero entries corresponding to the edges of the graph (the diagonal entries are not restricted). We compute the minimum rank and realizing matrices for the graph powers of paths. We also define a variant of G^r with edges

$$\{(u,v) \mid \text{there exists a walk of length } \textit{exactly } r \text{ from u to v}\}$$

and again compute minimum rank and realizing matrices of powers of paths. We also obtain some results for minimum ranks of our variant powers of cycles and trees.

This research was started at the American Institute of Mathematics workshop "Spectra of families of matrices described by graphs, digraphs, and sign patterns." (Received September 15, 2008)

1046-15-1455 **Olga Pryporova*** (olgav@iastate.edu), Iowa State University, Ames, IA. *Diagonal and D convergence of matrices.*

A complex matrix A is D_R (respectively, D_C)-convergent if the spectral radius $\rho(DA) < 1$ for all real (respectively, complex) matrices D with $|D| \leq I$. A complex matrix A is diagonally convergent if there exists a positive diagonal matrix P such that $P - A^*PA$ is positive definite. I will discuss the relationships between D_R, D_C and diagonal convergence of matrices. (Received September 15, 2008)

1046-15-1520 **Carla D Martin*** (carlam@math.jmu.edu), Department of Mathematics and Statistics, James Madison University, MSC 1911, Harrisonburg, VA 22807, and **Misha E Kilmer** and **Lisa Perrone**. *A Higher-order Generalization of the Matrix SVD as a Product of Higher-order Tensors.* Preliminary report.

Traditionally, extending the Singular Value Decomposition (SVD) to higher-order tensors (multiway arrays) has involved a representation using the outer product of vectors. These outer products can be written in terms of the n-mode product, which can also be used to describe a type of multiplication between two tensors. We present a different type of higher- order generalization of the SVD where an order-p tensor is instead decomposed as a product of order-p tensors. In order to define this new notion, we define tensor-tensor multiplication in such a way so that it is closed under this operation. This results in new definitions for tensors such as the tensor transpose, inverse, and identity. A major motivation for considering this new type of tensor multiplication is to devise new types of factorizations for tensor which could then be used in applications such as data compression. We therefore present two strategies for compressing tensors which make use of our new tensor SVD and give some numerical comparisons to existing algorithms on synthetic data. (Received September 15, 2008)

1046-15-1746 **Carla Fidalgo*** (cfidalgo@isec.pt), Rua Pedro Nunes - Quinta da Nora, 3030-199 Coimbra, Portugal, and **Alexander Kovacec**, Largo D. Dinis, Apartado 3008, 3001-454 Coimbra, Portugal. *Roots of Polynomials and Linear Programming.* Preliminary report.

In connection with a problem on sums of square representations we came up with an infinite class of univariate polynomials for each of which we conjectured unicity of a positive root. None of the classical results or methods like Descartes' rules and its extensions by Laguerre, Sturm's theorem, or more generally quantifier elimination, etc. would allow us to decide the conjecture. We then found that by means of a reformulation of the question via Linear Programming we could reduce it to a problem about an (infinite) class of lacunary polynomials with 11 terms. With this approach now a proof of the conjecture for all polynomials of degree up to several hundreds should be possible while it also led us in a natural way to find a counter example of degree 650. More important than the specific result seems to be the apparently new method we employed. Joint work with my supervisor, Alexander Kovacec. (Received September 16, 2008)

1046-15-1807 **Chenying Wang*** (wang_c@math.psu.edu), 109 McAllister, State College, PA 16803. *LDPC codes and Ramanujan graphs.*

Ramanujan graphs are optimal expanders. They are sparse regular graphs with large girth. These properties make them good candidates to be used to associate LDPC codes. Rosenthal and Vontobel were the first to construct LDPC codes based on Ramanujan graphs. Recently, a family of LDPC codes called $LU(m,q)$, where q is a prime power and $m \geq 2$, was constructed by using certain q-regular bipartite graphs as Tanner graphs. In this talk we discuss the distribution of the eigenvalues of the Tanner graphs of $LU(2,q)$ and $LU(3,q)$. We showed that the largest non-trivial eigenvalue of an $LU(2,q)$ code is $\sqrt{q}$ for all q, and that of an $LU(3,q)$ code is $\sqrt{2q}$ for q odd. Therefore the Tanner graphs of $LU(2,q)$ and $LU(3,q)$ are Ramanujan graphs, and $LU(2,q)$ and $LU(3,q)$ are good LDPC codes. (Received September 16, 2008)

1046-15-1831 **A. A. Jafarian*** (ajafarian@newhaven.edu), Department of Mathematics, University of New Haven, West Haven, CT 06516. *Linear Maps Preserving Diagonalizability on the Space of Upper Triangular Matrices.* Preliminary report.

We characterize bijective linear maps on the space of all infinite upper triangular matrices preserving diagonalizability. (Received September 16, 2008)

1046-15-1841 **Jason Grout*** (grout@iastate.edu), 396 Carver Hall, Department of Mathematics, Iowa State University, Ames, IA 50011. *Sage in an early-graduate research course investigating the minimum rank problem.*

This talk will discuss the use of Sage in a course designed to involve first and second-year graduate students in research. In this case, none of the students or the professor had had prior experience with Sage. Students collaborated using Sage and the included NetworkX package to investigate the minimum rank problem in combinatorial matrix theory. Various features of Sage (e.g., the included NetworkX package, the N.I.C.E. graph automorphism functionality, the online notebook interface, Cython integration, etc.) made Sage more useful than other commercial math software that was tried. In addition, the free nature of Sage made it more desirable for sharing research with other mathematicians since the mathematicians working on the problem do not all have access to the same commercial software. The results and source code of the research will be submitted as a paper soon. After the course, several students are continuing to use Sage in their other courses and one is planning to use Sage heavily in her masters thesis. (Received September 16, 2008)

1046-15-1902 **Erik G. Boman**, **David M. Day**, **Robert J. Hoekstra** and **Heidi K. Thornquist*** (hkthorn@sandia.gov), P.O. Box 5800, Mail Stop 0316, Albuquerque, NM 87185-0316. *Linear Algebra Challenges in Parallel Circuit Simulation.*

While direct linear solvers have long been regarded as a requirement for successful circuit simulation, the simulation of large-scale digital circuits is necessitating the use of iterative linear solvers. However, the linear systems generated through circuit simulation can prove to be challenging for the conventional matrix ordering, load balancing, and preconditioning techniques due to their heterogeneous matrix structure. We will discuss why these linear systems can be difficult for iterative methods to solve as well as some of the graph techniques employed by the Xyce circuit simulation code to address these challenges. Furthermore, we will also discuss ongoing work in parallel partitioning and preconditioning techniques that have proven useful for the simulation of some large-scale digital circuits. (Received September 16, 2008)

1046-15-1903 **Colin Garnett*** (cgarnett@uwyo.edu), 1000 E. University, Department of Mathematics, Laramie, WY 82071. *Minimum rank of skew-symmetric matrices described by a graph.*

The problem of determining the minimum rank of among the skew-symmetric matrices with a given zero-nonzero pattern is discussed, and related to recent developments regarding the minimum rank of other families of matrices. This work is the result of a research group of graduate students and faculty started at the IMA 2008 Summer school. Participating researchers are: Mary Allison, Elizabeth Bodine, Luz DeAlba, Joyati Debnath, Laura DeLoss, Wilson Florero, Colin Garnett, Jason Grout, Leslie Hogben, Bryan Shader, and Amy Wangsness Wehe. (Received September 16, 2008)

1046-15-1959 **Gregory V Bard*** (bard@fordham.edu), Department of Mathematics, John Mulcahey Hall, Room 421, Fordham University, The Bronx, NY 10458, and **Robert Miller** (rlm@rlmiller.org). *Ultra-Sparse Matrix Reduction to Reduced Row-Echelon Form for matrices over $GF(2)$.*

Reducing matrices over $GF(2)$ to their Reduced Row-Echelon Form is a core part of the F4 algorithm for solving polynomial systems of equations over finite (or other) fields. This in turn is a crucial step in algebraic cryptanalysis. Furthermore, the matrices are often sparse.

Treating sparse matrices as if they were dense is unwise, because Gaussian Elimination will cause the matrix to become dense after a few small iterations. A long series of known techniques relating to graph theory exist for the identical problem over the real numbers, but require modification to work over $GF(2)$. In particular, the standard technique (the "min degree algorithm") works on positive semi-definite symmetric matrices. For matrices M that are not symmetric, or positive semi-definite, or even those that are rectangular, M^TM is used instead, which will be positive semi-definite and symmetric. But over characteristic two, this fails because the null-space of M^TM might be larger than the null-space of M—impossible in characteristic zero. We construct a new algorithm, using similar methods, but taking advantage of the properties of the relationships between matrices and graphs that remain unchanged when moving from characteristic zero to characteristic two. (Received September 16, 2008)

1046-15-1998 **Troy Banks*** (tvbanks@salisbury.edu), Department of Mathematics & Computer Science, Salisbury University, 1101 Camden Avenue, Salisbury, MD 21801. *On the structure of some classes of invariant kernels.* Preliminary report.

We study the structure of a certain class of Toeplitz-like positive definite kernels on the free semigroup on N generators. We explore some possible applications to multiscale processes and to learning with kernels. Associated classes of orthogonal polynomials are also investigated. (Received September 16, 2008)

1046-15-2007 **B David Saunders*** (saunders@udel.edu), Computer and Information Sciences Department, University of Delaware, Newark, DE 19716. *On matrix rank modulo small primes.* Preliminary report.

I will present methods to compute rank of dense and sparse matrices mod very small primes such as 2 and 3. Arithmetic details, data organization, and algorithm choices available in LinBox will be discussed. (Received September 16, 2008)

16 ► Associative rings and algebras

1046-16-204 **James J Zhang***, Department of Mathematics, Box 354350, University of Washington, Seattle, WA 98195. *Hopf algebras of low GK-dimension.*

We present some recent results about noetherian Hopf algebras of low GK-dimension by Ken Brown, Ken Goodearl, Diming Lu and Quanshui Wu. (Received August 18, 2008)

1046-16-259 **George M. Bergman*** (gbergman@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94720-3840. *An inner automorphism is only an inner automorphism, but an inner endomorphism can be something strange.*

The inner automorphisms of a group G can be characterized in a purely category-theoretic fashion, as those automorphisms of G that can be extended, in a functorial manner, to all groups H given with homomorphisms $G \to H$. (Unlike the group of inner automorphisms, the group of such systems of automorphisms is always isomorphic to G.) A similar characterization holds for inner automorphisms of an associative algebra R over a field K.

If one substitutes "endomorphism" for "automorphism" in these considerations, then in the group case, the only additional example is the trivial endomorphism; but in the K-algebra case, an unfamiliar construction (known to functional analysts) also comes up.

The preprint also investigates some similar further cases, about which I will not have time to say much in the talk; in particular, derivations of associative algebras, and endomorphisms and derivations of Lie algebras. (Received August 24, 2008)

1046-16-419 **S K Jain*** (jain@math.ohiou.edu), Department of Mathematics, Ohio University, Athens, OH 45701, **Surjeet Singh** (ossinghpal@yahoo.co.in), Department of Mathematics, Panjab University, Chandigarh, India, and **Ashish K Srivastava** (asrivas3@slu.edu), Department of Mathematics and CS, St. Louis University, St. Louis, MO 63103. *ON Σ-q RINGS.*

Nakayama (Ann. of Math. 42, 1941) showed that over an artinian serial ring every module is a direct sum of uniserial modules. Hence artinian serial rings have the property that each right (left) ideal is a finite direct sum of quasi-injective right (left) ideals. A ring with the property that each right (left) ideal is a finite direct sum of quasi-injective right (left) ideals will be called a right (left) Σ-q ring. For example, commutative self-injective rings are Σ-q rings. In this paper, various classes of such rings that include local, simple, prime, right non-singular right artinian, and right serial, are studied. Prime right self-injective right Σ-q rings are shown to be simple artinian. Right artinian right non-singular right Σ-q rings are upper triangular block matrix rings over rings which are either zero rings or division rings. In general, Σ-q ring is not left-right symmetric nor is it Morita invariant.

(Joint work with Surjeet Singh and Ashish K. Srivastava, To appear in the Journal of Pure and Applied Algebra) (Received September 01, 2008)

1046-16-420 **Gary F. Birkenmeier**, **Barbara L. Osofsky*** (osofsky@math.rutgers.edu), **Jae Keol Park** and **S. Tariq Rizvi**. *Properties of injective hulls of a ring having a compatible ring structure.* Preliminary report.

The injective hull $E(R_R)$ of a ring R has a unique structure as a ring whose multiplication is compatible with R-module multiplication if $E(R_R)$ is a rational extension of R_R. There are known examples where such a compatible ring structure exists when $E(R_R)$ is a not a rational extension of R_R, and other examples where such a compatible ring structure on $E(R_R)$ cannot exist. We discuss several examples, and then study the case where R is an Artin algebra. For example, if R is an Artin algebra, then $E(R_R)$ has a set theoretically unique structure as a ring whose multiplication is compatible with R-module multiplication iff $E(R_R)$ is a rational extension of R_R; if such a structure exists, then $E(R_R)$ is a quasiFrobenius ring under it. We also consider the question in the Artin algebra case of whether such a ring structure is unique up to isomorphism, and when it might exist. (Received September 01, 2008)

1046-16-451 **Jason P. Bell*** (jpb@math.sfu.ca), Simon Fraser University, 8888 University Drive, Burnaby, B.C. V5A 1S6, Canada. *Centralizers in domains of low Gelfand-Kirillov dimension.* Preliminary report.

Let a be an element in an algebra A. We study the centralizer $C(a;A)$ of a in A. We show that if A is a finitely-generated domain of Gelfand-Kirillov dimension d then either the centralizer of a has Gelfand-Kirillov dimension at most $d-1$, or a is algebraic over the centre of the quotient division algebra of A. As a result, we show that if A is a finitely generated complex noetherian domain of GK dimension 3 then the centralizer of a non-scalar element of a satisfies a polynomial identity. (Received September 03, 2008)

1046-16-943 **Kenneth L. Price*** (pricek@uwosh.edu), UW Oshkosh, 800 Algoma Boulevard, Oshkosh, WI 54901. *A Domain Test for Lie Color Algebras.*

Lie color algebras are generalizations of Lie superalgebras and graded Lie algebras. We begin with background on Lie color algebras and show the universal enveloping algebra of a Lie color algebra can be very different from that of an ordinary Lie superalgebra. We describe a test which uses Gröbner basis methods to determine when the universal enveloping algebra is a domain. This is applied in an example to show the universal enveloping algebra may be a domain even if it contains torsion elements and the base field is algebraically closed. This cannot happen for graded Lie algebras or Lie superalgebras. (Received September 12, 2008)

1046-16-994 **Lia Vaš*** (l.vas@usp.edu), University of the Sciences in Philadelphia, 600 S 43rd St., Philadelphia, PA 19104. *Von-Neumann-algebra-like rings and the answer to a S. K. Berberian's question.*

When von Neumann algebras emerged from operator theory and started attracting the attention of a wider mathematical public, the need to axiomatize at least a part of theory of von Neumann algebras became readily apparent. This resulted in increased interest in the classes of rings and algebras such as Baer *-rings, Rickart C*-algebras, and others. As a result, "rings of operators" can be studied without involving sometimes rather complex methods of operator theory.

We shall concentrate on a class of Von-Neumann-algebra-like Baer *-rings defined by nine axioms. The last two of these nine axioms are particularly strong. We prove that the ninth axiom follows from the first seven and demonstrate that this gives an affirmative answer to the question of S. K. Berberian if a Baer *-ring R satisfies the first seven axioms, is the matrix ring $M_n(R)$ a Baer *-ring. (Received September 13, 2008)

1046-16-1021 **Edward S Letzter*** (letzter@temple.edu), Department of Mathematics, Temple University, Philadelphia, PA 19122. *On Noetherian Skew Power Series Rings.* Preliminary report.

This talk is on skew power series rings $T := R[[y;\tau,\delta]]$, for suitably conditioned right noetherian complete semilocal rings R, automorphisms τ of R, and τ-derivations δ of R. These rings were introduced by Venjakob, motivated by issues in noncommutative Iwasawa theory. We focus on questions concerning the extension and contraction of ideals between R and T, discussing both recent results and open problems. (Received September 13, 2008)

1046-16-1084 **Linhong Wang*** (lwang@selu.edu), Department of Mathematics, SLU 10687, Hammond, LA 70402. *Nonsplit module extensions over a non-noetherian ring.* Preliminary report.

Let R be the associative algebra generated by two elements x and y with defining relation $yx = 1$. A complete description of simple modules over R is obtained by using the results of Irving and Gerritzen. We examine the short exact sequence of the form $0 \longrightarrow U \longrightarrow E \longrightarrow V \longrightarrow 0$, where U and V are simple R-modules, and give an explicit classification of nonsplit extensions of simple modules over R. (Received September 14, 2008)

1046-16-1091 **Martin W Montgomery*** (mmontgomery@piedmont.edu), 165 Central Ave, Demorest, GA 30535. *Square-Free Rings and their Automorphism Group.*

Finite-dimensional square-free K-algebras have been completely characterized by Anderson and D'Ambrosia as certain semigroup algebras $A \cong K_\xi S$ over a square-free semigroup S twisted by some $\xi \in Z^2(S, K^*)$, a two-dimensional cocycle of S with coefficients in the group of units K^* of a field K. D'Ambrosia extended the definition of square-free to artinian rings with unity and showed every square-free ring has an associated division ring D and square-free semigroup S. We show a square-free ring R can be characterized as a semigroup ring over a square-free semigroup S twisted by some $(\alpha, \xi) \in Z^2(S, D^*)$, a two-dimensional cocycle of S with coefficients in the nonabelian group of units D^* of a division ring D. Also, to each square-free ring $R \cong D^\alpha_\xi S$ there exists a short exact sequence

$$1 \longrightarrow H^1_{(\alpha,\xi)}(S, D^*) \longrightarrow \text{Out } R \longrightarrow \text{Stab}_{(\alpha,\xi)}(\text{Aut } S) \longrightarrow 1.$$

connecting the outer automorphisms of R to cohomology groups related to S and D. (Received September 14, 2008)

1046-16-1155 **David Harbater*** (harbater@math.upenn.edu), **Julia Hartmann** and **Daniel Krashen**. *Admissible group actions on curves.* Preliminary report.

Let G be a finite group that acts on a curve Y over a field K, and let $X = Y/G$. Let E and F be the function fields of Y and X. We say that the action of G is *admissible* if for some division algebra D over F, the field E is a maximal subfield of D containing F. Using patching, we classify the groups G that have an admissible action with quotient curve X, in the case that $K = k((t))$ with k algebraically closed. This is a geometric analog of a conjecture of Schacher concerning group actions on number fields. (Received September 14, 2008)

1046-16-1192 **Ryszard Mazurek*** (mazurek@pb.bialystok.pl), Faculty of Computer Science, Bialystok Technical University, Wiejska 45A, 15-351 Bialystok, Poland. *Skew generalized power series rings.*

A skew generalized power series ring $R[[S, \omega]]$ consists of all functions from a strictly (partially) ordered monoid S to a coefficient ring R whose support contains neither infinite descending chains nor infinite antichains, with pointwise addition, and with multiplication given by convolution twisted by an action ω of the monoid S on the ring R. Special cases of the construction are skew polynomial rings, skew Laurent polynomial rings, skew power series rings, skew Laurent series rings, skew group rings, Mal'cev-Neumann Laurent series rings, the "untwisted" versions of all of these, and generalized power series rings.

We will give some necessary and sufficient conditions for the skew generalized power series ring $R[[S, \omega]]$ to be, respectively, von Neumann regular, strongly regular, reduced, right Bezout, right Gaussian, right distributive, right uniserial, or to have weak dimension less or equal to one, or to satisfy the ascending chain condition for principal left (right) ideals. We will use skew generalized power series rings to propose a unified approach to various generalizations of Armendariz rings. This is joint work with Greg Marks and Michał Ziembowski. (Received September 15, 2008)

1046-16-1202 **Michael Cuntz** and **Christopher Goff*** (cgoff@pacific.edu), Mathematics Department, 3601 Pacific Ave, Stockton, CA 95211. *An isomorphism between the fusion algebras of V_L^+ and type $D^{(1)}$ level 2.*

This talk will show that the fusion algebra of the vertex operator algebra V_L^+ (where L is a rank 1 even lattice) is isomorphic to the fusion algebra of the affine Kac-Moody Lie algebra of type $D^{(1)}$ at level 2. (Received September 15, 2008)

1046-16-1241 **Radmila Sazdanovic*** (radmila@gwu.edu), The George Washington University, Department of Mathematics (Monroe Hall Rm240), 2115 G street NW, Washington, DC 20052, and **Mikhail Khovanov**. *Plane diagrammatics and categorification.* Preliminary report.

We introduce a calculus of planar diagrams with the height function that leads to categorification of some basic special functions. (Received September 15, 2008)

1046-16-1359 **Zinovy Reichstein*** (reichst@math.ubc.ca), Department of Mathematics, University of British Columbia, Vancouver, BC V6T1Z2, Canada. *Essential dimension of central simple algebras.*

Informally speaking, the essential dimension of an algebraic object (e.g., a finite-dimensional algebra or a quadratic form) is the minimal number of independent parameters one needs to define it. This notion has rich connections to various classical problems in algebra, including the algebraic form of Hilbert's 13th problem, Albert's cyclicity problem, Serre's Conjecture II, and the Serre-Grothendieck theory of "special groups".

In the context of central simple algebras this invariant first came up in a 1967 paper of C. Procesi, who showed that the essential dimension of a central simple algebra of degree n is bounded from above by n^2. Computing the exact value for a generic division algebra of degree n remains an open problem. In this talk I will discuss known results in this area, including recent joint work with A. Meyer on the essential dimension of a pair (A, L), where A/K is a division algebra of degree n and L/K is a maximal subfield of A. (Received September 15, 2008)

1046-16-1418 **Ivo Herzog*** (iherzog@lima.ohio-state.edu), Department of Mathematics, The Ohio State University at Lima, 4240 Campus Dr., Lima, OH 45804–357. *Homology of a Ring.*

We will describe how a complex may be associated to a pointed abelian category in such a way that, for the case of the free abelian category $\mathrm{Ab}(R)$ over a ring R, the homology in lower dimensions is closely related to the K-theory of $\mathrm{Ab}(R)$. (Received September 15, 2008)

1046-16-1580 **Dolors Herbera*** (dolors@mat.uab.cat), Departament de Matematiques, Universitat Autonoma de Barcelona, E-08193 Bellaterra, Barcelona, Spain, and **Pavel Prihoda**. *Big Projective Modules over Noetherian Semilocal Rings.*

Let R be a ring. The set $V^*(R)$ of isomorphism classes of countably generated projective right R-modules has a structure of commutative monoid with the sum induced by the direct sum of countably generated projective modules. For example, if $D_1, \dots, D_k$ denote division rings then for a semisimple artinian ring $M_{n_1}(D_1) \times \cdots \times M_{n_k}(D_k)$ such monoid is isomorphic to $(\mathbb{N}^*)^k$, where $\mathbb{N}^* = \mathbb{N} \cup \{\infty\}$.

Let R be a semilocal ring, i.e. a ring that is semisimple modulo its Jacobson radical. If $R/J(R) \cong M_{n_1}(D_1) \times \cdots \times M_{n_k}(D_k)$ then, a recent result of P. Prihoda, implies that $V^*(R)$ is isomorphic to a submonoid of $(\mathbb{N}^*)^k$. In this talk we shall present a characterization of such monoids when R is, in addition, a (two-sided) noetherian ring. (Received September 16, 2008)

1046-16-1602 **Alexander J Diesl*** (adiesl@bgsu.edu), Department of Mathematics and Statistics, Bowling Green State University, Bowling Green, OH 43403, and **Thomas J Dorsey** and **Warren Wm. McGovern**. *A Characterization of Certain Morphic Trivial Extensions.*

A ring R is called left morphic if for every $a \in R$ there is an element $b \in R$ such that $\mathrm{ann}_l(a) = Rb$ and $\mathrm{ann}_l(b) = Ra$. A ring is called morphic if it is both left and right morphic. Morphic rings are a natural generalization of the classical unit regular rings. In this paper, we investigate when the trivial extension of a ring by a suitable bimodule is morphic. Among the classes of rings we investigate are left perfect rings, unit regular rings and commutative reduced rings. (Received September 16, 2008)

1046-16-1855 **Christopher Phan***, Department of Mathematics, 1222 University of Oregon, Eugene, OR 97403, and **Thomas Cassidy** and **Brad Shelton**. *The Yoneda algebra of a monomial $\mathcal{K}_2$ algebra.*

The Yoneda algebra of a Koszul algebra A is well understood as the quadratic dual $A^!$. We consider the case where the connected-graded algebra A is a monomial algebra in the more general class of $\mathcal{K}_2$ algebras introduced by Cassidy and Shelton. In this more general case, the Yoneda algebra has both binomial and monomial relations, which we describe. Furthermore, the Yoneda algebra is not necessarily one-generated and may not be $\mathcal{K}_2$. (Received September 16, 2008)

1046-16-1863 **David J Saltman*** (saltman@idaccr.org), Center for Communications Research, 805 Bunn Drive, Princeton, NJ 08540. *Quaternion algebras and their subfields.*

By a theorem of Amitsur, if D/F and E/F are finite dimensional division algebras with the same splitting fields, then D/F and E/F are closely related—they generate the same subgroup of the Brauer group. But the splitting fields used to prove this are large—are, in fact, the generic splitting fields. It is of interest to ask whether when D/F and E/F have the same finite dimensional splitting fields, or more specifically the same maximal subfields, whether the same result holds. When D/F (and E/F) are not quaternion algebras, counterexamples already exist for F a global field. We show that when F has 0 unramified Brauer group, and D/F and E/F have the same maximal subfields, then D is isomorphic to E. We will give the full elementary proof, and then discuss generalizations to higher cohomology due to Skip Garibaldi. (Received September 16, 2008)

1046-16-1877 **Jonathan Scott Brown*** (jbrown8@uoregon.edu), 1764 W. 9th Place, Eugene, OR 97402. *Representation theory of finite W-algebras and twisted Yangians.* Preliminary report.

Finite W-algebras are certain associative algebras associated to nilpotent orbits in semisimple Lie algebras. They are deformations of the universal enveloping algebra of the centralizer of the nilpotent orbit. In this talk I will explain how the finite W-algebras associated to a class of nilpotent orbits in classical Lie algebras are quotients of twisted Yangians. Using this and Molev's classification of finite dimensional irreducible representations of twisted Yangians, we deduce the classification of finite dimensional irreducible representations of these finite W-algebras, and relate it to a general conjecture of Brundan, Goodwin and Kleshchev which is phrased in terms of primitive ideals. (Received September 16, 2008)

1046-16-2001 **Thomas J. Dorsey*** (dorsey@ccrwest.org), 4320 Westerra Ct., San Diego, CA 92126, and **Alexander J. Diesl** (adiesl@bgsu.edu). *Strongly clean matrix rings.*

An element of a ring is said to be strongly clean if it is the sum of a unit and an idempotent which commute with one another. Previous work of the present authors together with G. Borooah characterized when a matrix ring over a commutative local ring is strongly clean, using a type of factorization (related to Hensel's Lemma) which we called an SRC factorization. In the present work, for an arbitrary (not necessarily commutative) ring, we introduce a type of ideal theoretic factorization which is equivalent to the notion of SRC factorization in the commutative local case. Moreover, we show that this new notion characterizes when a companion matrix over an arbitrary ring is strongly clean (generalizing work of Yang and Zhou in the local case), and we use this to characterize precisely when a matrix ring over an arbitrary commutative ring is strongly clean. (Received September 16, 2008)

1046-16-2035 **Aaron Lauve** (lauve@math.tamu.edu), Texas A&M University, Department of Mathematics, MS 3368, College Station, TX 77843-3368, and **Sarah Witherspoon*** (sjw@math.tamu.edu), Texas A&M University, Department of Mathematics, MS 3368, College Station, TX 77843-3368. *Nichols algebras in positive characteristic.*

Nichols algebras were introduced by Nichols in 1978 and have reappeared in several places since (including work on the Schubert calculus and quantum enveloping algebras). More recently, they appear as key players in the classification of pointed Hopf algebras (which are finite dimensional if and only if their Nichols subalgebras are). The goal of this talk is to advertise one particular realization of Nichols algebras based on the Hopf quivers of Cibils and Rosso. It is hoped that this model will eventually be useful in determining large families of Nichols algebras which are finite dimensional. Here, we present a new family of such algebras in positive characteristic. (Received September 16, 2008)

17 ► Nonassociative rings and algebras

1046-17-70 **Victor Protsak***, Malott Hall, Ithaca, NY 14853. *Noncommutative linear algebra and primitive ideals.*

Many classical results about matrices involving the determinant, characteristic and minimal polynomials admit natural noncommutative generalizations. For example, the Capelli identity expresses a relation between the characteristic polynomials of AB and A^tB^t for certain matrices of differential operators. This is what I mean by "noncommutative linear algebra".

While already interesting in itself, this formalism throws new light on the known subtle differences between primitive ideals in the universal enveloping algebras and the coadjoint orbits. (Received July 21, 2008)

1046-17-72 **Audrey Malagon*** (amalago@emory.edu), Math & Science Center, 400 Dowman Dr, W401, Atlanta, GA. *Killing Forms of Lie Algebras.*

One approach to the problem of classifying Lie algebras is to find invariants. One such invariant is the Killing form. In this talk I will give a formula for computing the Killing form of an isotropic Lie algebra defined over an arbitrary field of characteristic zero, based on the Killing form of a subalgebra containing its anisotropic kernel. I will then explicitly compute the Killing form for several Lie algebras of exceptional type and give a general formula for the Killing form of all inner type Lie algebras of type E_6, including the anisotropic ones. (Received August 26, 2008)

1046-17-80 **Fred W. Helenius*** (fheleni@emory.edu). *Freudenthal Triple Systems by Root System Methods.*

A *Freudenthal triple system* (FTS) is a vector space endowed with a quartic form and a bilinear form such that a triple product defined from these forms satisfies a specific identity. The original example is the 56-dimensional representation of E_7; here, the group stabilizing both forms is precisely E_7. M. Rost observed that an 8-dimensional vector space with quartic form occurring in a paper of M. Bhargava was, with a suitable bilinear form, a FTS; he asked what the stabilizer of the forms was in this case. We answer his question by showing that both his example and the 56-dimensional representation of E_7 are instances of a general construction that reveals a FTS within any Lie algebra of type D or E, with natural definitions for the quartic and bilinear forms. (Received July 21, 2008)

1046-17-296 **Audrey Malagon*** (amalago@emory.edu), 400 Dowman Dr., Atlanta, GA 30322. *A New Approach to Killing Forms.*

This poster will explain a method for computing the Killing form of an isotropic Lie algebra over a field of characteristic zero, based on the Killing form of a subalgebra containing its anisotropic kernel. I will display explicit formulas for the Killing form of several Lie algebras of exceptional type and give a formula for the Killing form of all inner type Lie algebras of type E_6, including the anisotropic ones. (Received August 25, 2008)

1046-17-445 **Julie C Beier*** (beier_jc@mercer.edu), Mercer University, Department of Mathematics, 1400 Coleman Avenue, Macon, GA 31207. *Combinatorics of Crystal Bases for Certain Demazure Modules.*

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. (Received September 03, 2008)

1046-17-523 **Vyacheslav Futorny*** (vfutorny@gmail.com), IME-USP, Caixa Postal 66281, Sao Paulo, Brazil, and **Iryna Kashuba**. *Induced modules for Affine Kac-Moody algebras.* Preliminary report.

The category of weight modules with nonzero central charge over Affine Lie algebras will be discussed. Though a classification of irreducible modules with finite-dimensional weight spaces in this category is known, the general classification problem remains open. A progress is made in this direction by studying the subcategory of induced modules. Their structure is described using certain category equivalence. (Received September 05, 2008)

1046-17-798 **Lei Zhao*** (lz4u@virginia.edu), Department of Mathematics, University of Virginia, Charlottesville, VA 22903, and **Weiqiang Wang**. *Representations of Lie Superalgebras in Prime Characteristic.*

We study the modular representation theory of basic classical Lie superalgebras and the queer Lie superalgebra over an algebraically closed field of characteristic $p > 2$. In particular, we formulate a superalgebra generalization of the celebrated Kac-Weisfeiler Conjecture, which exhibits a mixture of p-power and 2-power divisibility of dimensions of modules. We establish the Conjecture for basic classical Lie superalgebras, and for the queer Lie superalgebra with nilpotent p-characters. (Received September 11, 2008)

1046-17-871 **Chris Kennedy*** (christopher.kennedy@cnu.edu), Christopher Newport University, 1 University Place, Newport News, VA 23606. *Simple and Nearly Simple Deep Matrix Algebras.*

The deep matrix algebra $\mathcal{DM}(X, \mathbb{K})$ based on a set X over a field $\mathbb{K}$ is a deeper version of a standard matrix algebra. We present several key associative subalgebras of $\mathcal{DM}(X, \mathbb{K})$, and use these in the construction and study of several deep matrix Lie algebras. These are shown to be either simple or nearly simple (possessing a unique non-zero proper ideal) depending on the cardinality of the set X. Cartan subalgebras are constructed and two of the Lie algebras are then decomposed with respect to the adjoint action of these subalgebras. In the process, an infinite dimensional analogue to $\mathfrak{sl}_2(\mathbb{K})$ is naturally realized as a key subalgebra in deep matrix Lie algebras. (Received September 12, 2008)

1046-17-952 **Irfan Bagci*** (bagci@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602. *Cohomology and Support Varieties for Cartan Lie superalgebras.*

Let g be Cartan Lie superalgebra of type W or S. In this talk I will calculate the relative cohomology ring of g relative to the graded zero component and show that this ring is finitely generated. This allows one to define support varieties for finite-dimensional g-modules which are completely reducible over the graded zero component. We calculate the support varieties of all simple modules in this category. Remarkably our computations coincide with the prior notions of atypicality for Cartan type superalgebras due to Serganova. I will also present a new theorem on realizability of support varieties. The results about type W is joint work with Jonathan Kujawa and Daniel Nakano. (Received September 13, 2008)

1046-17-1045 **Andre G. Leroy*** (leroy@euler.univ-artois.fr), Faculté Jean Perrin, 23 Rue Jean Souvraz, 62307 Lens, France. *Quasi-duo skew polynomial rings and graded rings.*

This is a joint work with J. Matczuk and E. Puczylowski (Warsaw university).

Quasi-duo $\mathbb{Z}$-graded rings are described. These results are then applied to get characterizations of quasi-duo skew polynomial rings and skew Laurent polynomial rings.

Let R be a $\mathbb{Z}$-graded ring. Recall that $R = \bigoplus_{n\in\mathbb{Z}} R_n$, the direct sum of additive subgroups R_n, with $R_n R_m \subseteq R_{n+m}$ for all $n, m \in \mathbb{Z}$. We denote by $\mathcal{A}$ the set of all maximal right ideals M of R such that $R_n \not\subseteq M$, for some $0 \neq n \in \mathbb{Z}$. Set $A(R) = \bigcap_{M\in\mathcal{A}} M$.

Theorem: A $\mathbb{Z}$-graded ring R is quasi-duo if and only if R_0 is quasi-duo and $R/A(R)$ is a commutative ring.

We apply this result to obtain a characterization of right (left) quasi-duo skew polynomial rings of endomorphism type and skew Laurent polynomial rings. (Received September 14, 2008)

1046-17-1334 **John Massman*** (massman@rose-hulman.edu), Rose-Hulman Institute of Technology, 5500 Wabash Ave CM 4043, Terre Haute, IN 47803. *4-Dimensional Non-Associative Division Algebras.*

The classification of n-dimensional non-associative division algebras over a finite field $\mathbb{F}_q$ is a classic problem, whose interest has been rekindled by its application to coding for cell phone transmissions. The classification is known for only a limited number of cases. The most general known result is when n is prime and q is sufficiently large. We extend the classification to the case when $n = 4$ and q is sufficiently large. (Received September 15, 2008)

1046-17-1546 **Sandeep Bhargava*** (bhargava@uwindsor.ca). *Intersection Matrix Algebras.* Preliminary report.

We look at BC_r-graded intersection matrix algebras that arise from multiply affinizing a Cartan matrix of a complex finite dimensional simple Lie algebra. The process is analogous to and extends the construction of an affine Kac-Moody Lie algebra. We will also examine the coordinate algebras that arise in the realizations of these intersection matrix algebras. (Received September 16, 2008)

18 ► Category theory; homological algebra

1046-18-395 **Michael A. Shulman*** (shulman@math.uchicago.edu), University of Chicago, Department of Mathematics, 5734 S. University Ave., Chicago, IL 60637. *Limits, derived functors, and homotopical category theory.*

The correspondence between homotopy theory and higher category theory is now well-known, but some notions in homotopy theory, such as fibrant and cofibrant objects and derived functors, do not translate in an obvious way to category theory. We argue that derived functors are a canonical way to "make a construction categorical enough," such as by replacing functors with pseudofunctors, or sheaves with stacks. This can either be done by modifying the construction itself, or by applying it only to "flexible" objects—which is where cofibrancy comes in. We illustrate by comparing (enriched) homotopy limits to higher-categorical limits. (Received August 30, 2008)

1046-18-596 **John C. Baez*** (baez@math.ucr.edu), Department of Mathematics, University of California, Riverside, CA 92521. *Groupoidification.*

There is a systematic process that turns groupoids into vector spaces and spans of groupoids into linear operators. "Groupoidification" is the attempt to reverse this process, taking familiar structures from linear algebra and enhancing them to obtain structures involving groupoids. Like quantization, groupoidification is not entirely systematic. However, examples show that it is a good thing to try! For example, groupoidifying the quantum harmonic oscillator yields combinatorial structures associated to the groupoid of finite sets, while groupoidifying the q-deformed oscillator yields structures associated to finite-dimensional vector spaces over the field with q elements. Starting with flag varieties defined over the field with q elements, we can also groupoidify Hecke and Hall algebras. (Received September 08, 2008)

1046-18-607 **M Mackaay*** (mmackaay@ualg.pt), Universidade do Algarve, Departamento de Matematica, Campus de Gambelas, 8005-139 Faro, Portugal, and **M Stosic** and **P Vaz**. *The 1,2-coloured HOMFLY-PT link homology.*

This is joint work with Marko Stosic and Pedro Vaz. In my talk I will show how to generalize the triply graded HOMFLY-PT link homology, due to Khovanov and Rozansky, to links whose components are labelled 1 or 2. We use the approach with bimodules and Hochschild homology, which was introduced by Khovanov for the ordinary HOMFLY-PT link homology. (Received September 09, 2008)

1046-18-738 **Mikhail Khovanov*** (khovanov@math.columbia.edu). *Diagrammatics of biadjoint functors and beyond.*

We review a diagrammatic interpretation of biadjointness and abundance of biadjoint functors in algebra and topology. Examples will be given that build up on these diagrammatics to categorify various algebras of interest. (Received September 10, 2008)

1046-18-1057 **Alexander E Hoffnung*** (alex@math.ucr.edu). *A categorification of Hecke algebras.*

Given a Dynkin diagram and the finite field F_q, where q is a prime power, we get a finite algebraic group G_q. We will show how to construct a categorification of the Hecke algebra $H(G_q)$ associated to this data. This is an example of the Baez/Dolan program of "Groupoidification", a method of promoting vector spaces to groupoids and linear operators to spans of groupoids. For example, given the A_2 Dynkin diagram, for which $G_q = SL(3, q)$, the spans over the G_q-set of complete flags in F_q^3 encode the relations of the Hecke algebra associated to $SL(3, q)$. Further, we will see how categorified relations of the Hecke algebra correspond to incidence relations in projective plane geometry. (Received September 14, 2008)

1046-18-1244 **Ben Webster*** (bwebster@math.mit.edu), MIT, Department of Mathematics, Room 2-306, 77 Massachusetts Avenue, Cambridge, MA 02139. *A categorification of quantum tangle invariants via quiver varieties.* Preliminary report.

We show how, building on the work of Zheng on categorification of tensor products of integrable representations of quantum groups, one can use the geometry of quiver varieties to construct a categorical lift of the R-matrix, ribbon element, evaluation and coevaluation between these categories. This allows for the construction of functor-valued invariants of tangles which descend to the usual Reshetikhin-Turaev invariants, and in particular knot invariants valued in bigraded vector spaces. (Received September 15, 2008)

1046-18-1466 **Niles Johnson***, Department of Mathematics, 5734 S. University Avenue, Chicago, IL, IL 60637. *Morita theory and Azumaya objects in bicategorical contexts.*

Morita theory provides a wonderful first example of bicategorical structure in classic algebra. Generalizations of the Picard group, Azumaya algebras, and the Brauer group are now a part of higher-categorical folklore. However, these are important algebraic concepts not only because they have pleasing definitions but also because they are calculationally accessible. This talk will explain how to generalize those results from algebra which make these concepts so accessible, and describe some examples of interest to topologists and algebraists. The essential tools: duality and our friend the (bicategorical) Yoneda lemma. (Received September 15, 2008)

1046-18-1839 **C. Joanna Su*** (jsu@providence.edu), 549 River Avenue, Providence College, Dept. of Mathematics and Computer Science, Providence, RI 02918. *Further Remarks on Fibration and Cofibration in Module Theory.*

Peter Hilton established the homotopy theory in module theory, which was parallel to the existing homotopy theory in topology, in the late 1950s. In an earlier paper, "Fibration and Cofibration in Module Theory," we defined the analogs of fibration and cofibration in module theory to those in topology. Especially, we proved the existence of the homotopy exact sequence of a fibration in module theory and its dual, the homotopy exact sequence of a cofibration in module theory. Ultimately, there are two sets of fibration and cofibration in module theory. In this talk, we discuss the other set, whose existence turns out to be automatic and has long been hidden in two known exact sequences. (Received September 17, 2008)

1046-18-2112 **Ruth E Vanderpool*** (rvanderp@uoregon.edu), Department of Mathematics, 1222 University of Oregon, Eugene, OR 97405. *Homology of a chain complex over p-complete abelian groups.* Preliminary report.

P-complete abelian groups do not form an abelian category and thus behave unexpectedly when considering chain complexes and homology on these chain complexes. In particular, traditional homology fails to satisfy the axioms for a homology functor. I will explain where the failure occurs and introduce a number of other reasonable homology candidates that, surprisingly, also fail. (Received September 17, 2008)

19 ► K-theory

1046-19-700 **Seshendra Pallekonda*** (seshendrapallekonda@kings.edu), 133 River st, Admin 418, Wilkes-Barre, PA 18711. *Bounded Category of an Exact Category.*

Quillen's definition of higher K-groups of a ring R led to the idea of viewing algebraic K-theory of the ring R as a connective spectrum. A connective spectrum is one which has no homotopy groups in negative dimensions. Along the ideas of Quillen, the algebraic K-theory could be defined for an arbitrary exact category. But the connective spectra do not capture the negative K-groups. To address this we explain the problem of non-connective delooping. Given an exact category E, find an exact category such that its K-groups are the same as K-groups of E but with a dimension shift up by one. Once this is done, we can define all the other negative K-groups inductively.

In the case of an additive category, Pedersen and Weibel solved the problem of non-connective delooping using bounded category methods which proved to be useful in geometric topology to understand assembly maps. For general exact categories, where the exact sequences are not necessarily split, Schlichting solved the problem of non-connective delooping by algebraic methods. In this work, a possible candidate for the bounded category of an exact category is constructed which shares many properties of the bounded categories of Pedersen-Weibel.
(Received September 10, 2008)

1046-19-1134 **Florentiu Daniel Cibotaru*** (cibdan@yahoo.com), 1512 D Rosemary Lane, South Bend, IN 46637. *Localization Formulae in odd K-theory.* Preliminary report.

The spectral flow of a 1-parameter (continuous) family of self-adjoint matrices counts with sign the number of 0-eigenvalues. When dealing with families of self-adjoint, elliptic operators, the collection of spectral flows naturally defines a 1-cohomology class in the parametrizing space, which is nothing else but the first component of the odd cohomology class of the index associated to the family. We use symplectic geometry techniques to build geometric representatives of the Poincare duals for these classes. We give a spectral interpretation of these classes in the spirit of the spectral flow. (Received September 14, 2008)

20 ► Group theory and generalizations

1046-20-36 **Michael A. Ginter** (ginterma1@gcc.edu), **Susannah E. Johnson** (johnsonse1@gcc.edu) and **James E. McNamara*** (mcnamaraje1@gcc.edu), 200 Campus Drive, Number 2391, Grove City College, Grove City, PA 16127. *The Strong Symmetric Genus of Small Generalized Symmetric Groups.*

The generalized symmetric groups are defined to be $G(n,m) = \mathbb{Z}_m \wr \Sigma_n$ where $n, m \in \mathbb{Z}^+$. It can be shown that $G(n,m)$ is isomorphic to $HK \leq GL_n(\mathbb{C})$ where H is the group of $n \times n$ diagonal matrices with entries that are m^{th} roots of unity and K is the group of $n \times n$ permutation matrices. 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. This talk will discuss the strong symmetric genus of the groups $G(n,m)$ for $n = 3, 4, 5$, as well as establish an upper bound for the strong symmetric genus of all generalized symmetric groups. This project was supervised by Dr. Michael A. Jackson. (Received June 25, 2008)

1046-20-92 **David Hill*** (dhill1@math.berkeley.edu), **Jon Kujawa** and **Josh Sussan**. *Type Q Lie superalgebras and Degenerate Affine Sergeev Algebras.*

We define a functor between the category $\mathcal{O}$ for the Lie superalgebra $\mathfrak{q}(n)$ and the category of finite dimensional modules for the degenerate affine Sergeev algebra $\mathcal{S}^{\text{aff}}(d)$. Using this functor, we obtain a new classification of the simple finite dimensional modules for $\mathcal{S}^{\text{aff}}(d)$, originally obtained by Brundan and Kleshchev. Additionally, we give an explicit construction of the super-analogue of Zelevinski's segment representations. (Received July 22, 2008)

1046-20-124 **Delaram Kahrobaei*** (dkahrobaei@gc.cuny.edu), Mathematics Department, New York City College of Technology(CUNY), 300 Jay Street, Brooklyn, NY 11201. *Residual Solvability of One-relator Groups.*

Residual properties of groups is a term introduced by Philip Hall in 1954. Let X be a class of groups. G is residually-X if and only if, for every non-trivial element g in G there is an epimorph of G to a group in X such that the element corresponding to g is not the identity. Gilbert Baumslag showed in 1971 that a group G with a single defining relation in which there are no negative exponents, is residually solvable. The presenter has shown that the generalized free products of finitely generated nilpotent groups are almost residually solvable. She has

also found conditions where the generalized free products of doubles of free groups are residually solvable. She will use some of these results to show residual solvability of particularly one-relator groups. She will present examples of one-relator groups that are residually solvable, and that are not residually solvable. If time permits she will mention about applications of these results in true prosolvable completion of a group and related interesting open problems. (Received July 29, 2008)

1046-20-129 **Sean Cleary*** (cleary@sci.ccny.cuny.edu), Mathematics Department, R8133, The City College of New York, Convent Ave at 138th St, New York, NY 10031, and **Murray Elder**, **Andrew Rechnitzer** and **Jennifer Taback**. *Thompson's group F has no generic subgroups.*

Asymptotic group theory has been used to reveal weaknesses in some proposed cryptosystems due to the presence of generic free subgroups. In all known cases where free subgroups are present, they are generic in the sense that asymptotically, a random k-generated subgroup has probability one of being free of rank k. Thompson's group F contains no free subgroups, and we investigate asymptotic densities of subgroups with respect to two natural stratifications. We find a wide range of visible isomorphism classes of subgroups (that is, those with positive asymptotic density) and we find a new phenomenon of persistence, not seen in any other known examples. (Received July 31, 2008)

1046-20-185 **Jill E. Tysse*** (tysse@hood.edu), Department of Mathematics, Hood College, 401 Rosemont Avenue, Frederick, MD. *The Centers of Spin Hyperoctahedral Group Algebras.*

Generalizing the work of Farahat-Higman, we describe the even centers $\mathcal{Z}(Z_n)$ of integral spin hyperoctahedral group superalgebras, leading to universal algebras: the spin FH-algebras. We establish that the spin FH-algebra associated to the hyperoctahedral group is isomorphic to the spin FH-algebra associated to the spin symmetric group. Using this, we determine the algebra generators of the spin FH-algebras and of the even centers which turn out to involve odd Jucys-Murphy elements and Catalan numbers. (Received August 25, 2008)

1046-20-218 **Arturo Magidin*** (magidin@member.ams.org), Mathematics Department, University of Louisiana at Lafayette, P.O. Box 41010, Lafayette, LA 70504-1010, and **Robert F Morse** and **Azhana Ahmad**. *New classification of 2-generated p-groups of class 2.*

In this talk we will describe a new approach to classify 2-generated p-groups of class two, by recognizing each such group of order p^n as a central extension of $[G,G] \cong C_{p^\gamma}$ by $C_{p^\alpha} \times C_{p^\beta}$, where $\alpha+\beta+\gamma=n$.

We use the presentations to obtain the number of non-isomorphic 2-generator groups of class at most 2 and order p^n, some invariants of the groups, and to compute some of their homological invariants and properties (e.g., determine which ones are capable). (Received August 20, 2008)

1046-20-262 **TARALEE MECHAM*** (tmecham@math.ou.edu), 1009 EAST BROOKS ST. APT. A, NORMAN, OK 73071, and **Antara Mukherjee**. *Hyperbolic groups which fiber in infinitely many ways.*

We construct examples of free-by-cyclic hyperbolic groups which fiber in infinitely many ways over Z. The construction involves adding a specialized square 2-cell to a non-positively curved, squared 2-complex defined by labeled oriented graphs. The fundamental groups of the resulting complexes are hyperbolic, free-by-cyclic and can be mapped onto Z in infinitely many ways. (Received August 24, 2008)

1046-20-364 **Neil Hindman*** (nhindman@aol.com), Department of Mathematics, Howard University, Washington, DC 20059, and **Dona Strauss**. *Cartesian Products of Sets Satisfying the Central Sets Theorem.*

Central subsets of a discrete semigroup S have very strong combinatorial properties which are a consequence of the *Central Sets Theorem*. We show here that, not only is the Cartesian product of two central sets central, but in fact the Cartesian product of any two sets satisfying the conclusion of the Central Sets Theorem satisfies the conclusion of the Central Sets Theorem. Intimately related to the notion of a central set is something we call a J-set. These sets have many of the combinatorial properties of central sets and we show that this notion is also preserved under finite Cartesian products. Finally, we characterize when the Cartesian product of infinitely many sets is central. (Received August 28, 2008)

1046-20-397 **Thomas Langley*** (langley@rose-hulman.edu), **David Levitt** and **Joseph Rower**. *The probability that a product of n group elements is equal to a rearrangement of itself.*

A beautiful property of finite groups is that the probability that two elements commute is either 1, or at most 5/8. We generalize the equation $ab = ba$ by viewing ba as a permutation of ab and asking: What is the probability that a product $a_1a_2\cdots a_n$ is equal to a fixed rearrangement of itself? The answer is surprisingly nice, generalizing the 5/8 bound in a natural way. (Received August 30, 2008)

1046-20-648 **P. Christopher Staecker*** (cstaecker@messiah.edu), Box 3041, Messiah College, One College Ave, Grantham, PA 17027. *Singleton doubly-twisted conjugacy classes in free groups.*

We will show that a generic and easily verifiable combinatorial condition on pairs of homomorphisms will force a generic element of a finitely generated free group to be the only element of its doubly-twisted (Reidemeister) conjugacy class. (Received September 09, 2008)

1046-20-682 **Jane Gilman*** (gilman@andromeda.rutgers.edu), Mathematics Department, Rutgers University, Newark, NJ 07102, and **Linda Keen** (LINDA.KEEN@lehman.cuny.edu). *Palindromes and Discreteness Algorithms.*

Palindromes play an essential role in the discreteness algorithm for Fuchsian groups. It is well known that every primitive element of the free group on two generators is conjugate to either a palindrome in the generators or the product of two palindromes. The $PSL(2,\mathbb{R})$ discreteness algorithm determines whether or not a two generator non-elementary subgroup is discrete. If it is discrete, it is a Fuchsian group and the quotient of the upper-half-plane under its action is a Riemann surface of finite type. The discreteness algorithm runs through a series of words in the generators that are palindromes or products of two. Similarly, an algorithmic component of the $PSL(2,\mathbb{C})$ representation space will use a sequence of palindromes and products of two. We discuss the geometry of palindromes in the action of a two-generator group on hyperbolic three-space. We give a new iteration scheme for primitive elements of a free group in which the elements are either palindromes or the product of two palindromes (i.e. not simply conjugate to such) and obtain a discreteness condition for representations into $PSL(2,\mathbb{C})$ which gives insight into the algorithmic component of the representation space for three manifold and orbifold groups. (Received September 10, 2008)

1046-20-865 **Gary L Walls*** (gary.walls@selu.edu), Department of mathematics, SLU 10687, Hammond, LA 70402. *The Structure of Finite Groups with conditions on fixed-point-free Automorphims.*

An automorphism, α of a finite group, G, is said to be fixed-point-free (denoted by saying α is *f.p.f.*) provided for all $x \in G,\ \alpha(x) = x$ implies that $x = 1_G$.

Many papers have dealt with finite groups having fixed-point-free automorphisms. In a previous paper we showed that if α is a *f.p.f* -automorphism of a finite group G and $\alpha \in Fit(Aut(\mathrm{G}))$, then G must be abelian of a given particular structure.

This paper continues this investigation about the effects on a finite group and on its automorphism group when various conditions are applied to a fixed-point-free automorphism.
(Received September 12, 2008)

1046-20-866 **Luise-Charlotte Kappe*** (menger@math.binghamton.edu), State University of New York at Binghamton, Department of Mathematical Sciences, PO Box 6000, Binghamton, NY 13902-6000. *On n-Scorza groups.* Preliminary report.

We say a group is an n-Scorza group if it is the union of n proper subgroups and all of its proper homomorphic images are cyclic. It is well known that there are no 2-Scorza groups. According to a 1926 result by Scorza, a group is a 3-Scorza group if and only if it is isomorphic to the Klein Four group. Greco showed that a group is a 4-Scorza group if and only if it is isomorphic to the elementary abelian 3-group of rank 2 or the symmetric group on 3 letters.

In this talk we will give a characterization of the n-Scorza groups in the class of solvable groups as well as a classification of these groups for $n \leq 20$. (Received September 12, 2008)

1046-20-903 **Mary D. Shepherd*** (msheprd@nwmissouri.edu), 9112 County Road 62, Savannah, MO 64485. *Visualizing Groups and Subgroups in Counted Cross Stitch.*

Symmetry groups have a rich algebraic structure, and since many are non-Abelian, they comprise a nice set of examples in which to explore general ideas about groups, free from the hidden pitfalls that students sometimes encounter in Abelian groups. Using counted cross stitch examples created by the author, this talk will address: (1) visualizing the individual group elements and the group operation, (2) visualizing subgroups and cosets in both finite and infinite groups, and (3) exploring other properties and theorems related to groups and subgroups. We will begin these explorations looking at the finite group D4 and the infinite wallpaper group p4m. (Received September 12, 2008)

1046-20-929 **Joseph Evan*** (josephevan@kings.edu), Department of Mathematics, King's College, Wilkes-Barre, PA. *Characterizing Subgroups Satisfying the Strong Frattini Argument in a Direct Product.*

Recently, a group of authors has taken on the project of characterizing subgroup properties in direct products of groups. The ideal situation occurs when a subgroup property can be characterized by conditions from within the direct factors. For example, a subgroup N of the group $G_1 \times G_2$ is normal if and only if $\pi_i(N)/(N \cap G_i) \leq Z(G_i/(N \cap G_i))$ for $i = 1, 2$ where π_i refers to the natural projection of $G_1 \times G_2$ onto G_i.

A subgroup U of a group G *satisfies the Frattini argument in* G if for all normal subgroups K of G, we have $G = KN_G(U \cap K)$. A subgroup U of G then *satisfies the strong Frattini argument* in G if it satisfies the Frattini argument in every subgroup in which it is contained. Subgroups satisfying the strong Frattini argument are of interest in the study of finite solvable groups, where injectors are subgroups that satisfy the strong Frattini argument. In this talk, we will describe a characterization of subgroups of direct products of finite solvable groups that satisy the strong Frattini argument, and this characterization does in fact only require conditions from within the direct factors. (Received September 12, 2008)

1046-20-1006 **Gilbert Baumslag** and **Benjamin Fine*** (fine@mail.fairfield.edu), Department of Mathematics, North Benson Road, Fairfield, CT 06824, and **Douglas Troeger**. *CHALLENGE RESPONSE PASSWORD SECURITY USING COMBINATORIAL GROUP tHEORY.* Preliminary report.

With the increased use of bank cards and internet credit card transactions there is at present more than ever a need for secure password identification. For many online purchases this is being carried out by a challenged response system accompanying the password.

In this talk we present an alternative method for challenge response password verification using combinatorial group theory. The method uses the group randomizer system which is a computer program that is a subset of MAGNUS a much larger computer algebra system designed to handle algorithmic problems in combinatorial group theory.

These group theoretic techniques have several major advantages over other challenge response systems. They permit easy two-way authentication, there is an infinite and random supply of challenge questions and each password login amounts to a one-time keypad - hence strong security. We will present two relatively simple protocols. This is part of a larger project designed to store and encode information within finitely presented groups. (Received September 13, 2008)

1046-20-1073 **Peter A Linnell*** (linnell@math.vt.edu), Department of Mathematics, Virginia Tech, Blacksburg, VA 24061-0123. *Left ordered and discretely ordered groups.*

Let G be a group. I will show that the number of left orders on G is either finite or uncountable. Next if $<$ is a left order on G, then we say that it is discrete if G has a minimal positive element x under $<$; thus $1 < x$ and there is no $g \in G$ such that $1 < g < x$. I will discuss various properties and examples of this notion. Some of this is joint work with Akbar Rhemtulla and Dale Rolfsen. (Received September 14, 2008)

1046-20-1089 **Dongwen Qi*** (tychnov001@gmail.com), Department of Mathematics, Georgia Southwestern State University, 800 GSW State University Drive, Americus, GA 31709. *A note on irreducible, infinite Coxeter groups.*

A new proof is given for the statement: For an irreducible, infinite Coxeter group (W, S) and $w \in W$, if $wSw^{-1} = S$, then $w = 1$ (the identity element of W) (Received September 14, 2008)

1046-20-1137 **Brian Parshall***, Department of Mathematics, University of Virginia, Charlottesville, VA 22903. *Filtrations of Weyl modules.* Preliminary report.

This talk reports on current work with Leonard Scott. Let G be a semisimple, simply connected algebraic group defined over an algebraically closed field of positive characteristic p. For each dominant weight λ (taken with respect to some fixed set of positive roots), there is associated a Weyl module $\Delta(\lambda)$ and a reduced Weyl module $\Delta^{\text{red}}(\lambda)$. Each is obtained by reduction mod p from an appropriate lattice (the first involving the universal enveloping algebra of the complex Lie algebra associated to G and the second from the quantum enveloping algebra). We discuss the issue of whether each $\Delta(\lambda)$ has a filtration with sections of the form $\Delta^{\text{red}}(\mu)$. The answer is "no" if p is small (thanks to an interesting example shown to us by Will Turner). But we are able to prove some theorems of a positive nature which suggest the answer might be "yes" for large p. Some applications will also be touched upon. (Received September 14, 2008)

1046-20-1149 **Leonard L Scott***, Dept. Mathematics, The University of Virginia, Kerchof Hall, Cabell Drive, Charlottesville, VA 22903. *Cohomology of algebraic, quantum, and finite groups.*

I will discuss some interrelated issues for Ext and cohomology groups over algebraic, quantum, and finite groups of Lie type. The main focus will be on irreducible coefficient modules, though others will enter. Much of the work involves relatively recent results obtained with Ed Cline and Brian Parshall, as well as older work with these collaborators. In part, this recent work was motivated by the desire to better understand the reductions modulo p of char. 0 quantum irreducible modules at a pth root of unity, whose study was initiated by G. Lusztig and Z. Lin. But as our work evolved, we realized the results were very relevant to some asymptotic cohomology questions raised by Robert Guralnick for general finite groups. I will mention some of these questions, and also mention some additional relevant results obtained by the author in collaboration with Nanua Xi. (Received September 14, 2008)

1046-20-1195 **Carolyn Yackel*** (yackel_ca@mercer.edu). *Temari Math and Geometry on the Sphere.* Preliminary report.

We will discuss the interplay between mathematics and the craft of embroidered temari thread balls. Two different ways of classifying temari ball designs will be considered; one presented by Conway, Burgiel, and Goodman-Strauss in their recent book The Symmetries of Things and the other as a projection of polyhedra onto the sphere. One portion of the talk will demonstrate the use of temari as examples of spherical symmetries or polyhedral projections. The other half will focus on which symmetries or polyhedra can be realized in some mathematically exact sense given the restriction to temari techniques. (Received September 15, 2008)

1046-20-1211 **Andrew Francis** and **Lenny Jones*** (lkjone@ship.edu), Department of Mathematics, Shippensburg University, Shippensburg, PA 17257. *Quasi-Multiplicative Bases for the Center of the Iwahori–Hecke Algebra of Type A.* Preliminary report.

Let $Z(\mathcal{H}_n)$ denote the center of the Iwahori–Hecke algebra $\mathcal{H}_n$ of the symmetric group S_n over $\mathbb{Z}[q,q^{-1}]$, and let $p(n)$ be the number of partitions of n. A basis $\{b_1,b_2,\ldots,b_{p(n)}\}$ for $Z(\mathcal{H}_n)$ is called *quasi-multiplicative* if for any basis elements b_i and b_j, there exists a basis element b_k and a polynomial $f\in\mathbb{Z}[q,q^{-1}]$ such that $b_ib_j=fb_k$. If $f=1$ in all possible cases, then the basis is called *multiplicative.* An element $e\in Z(\mathcal{H}_n)$ is called *quasi-idempotent* if $e^2=fe$ for some polynomial $f\in\mathbb{Z}[q,q^{-1}]$. We show that any quasi-multiplicative basis for $Z(\mathcal{H}_n)$ must consist of quasi-idempotents, and we determine all such bases, up to scalars, when $n=3$ and $n=4$. In addition, we answer a question of Jie Du (private communication) by showing for all n that no multiplicative basis for $Z(\mathcal{H}_n)$ exists. (Received September 15, 2008)

1046-20-1224 **Christopher M Drupieski*** (cmd6a@virginia.edu), University of Virginia, Department of Mathematics, Kerchof Hall, Charlottesville, VA 22904. *Cohomology of finite-dimensional quantized enveloping algebras: the mixed case.*

Let k be an algebraically closed field. Let Φ be an indecomposable root system, and let U_ζ denote the corresponding quantized enveloping algebra (Lusztig integral form) with parameter q specialized to a primitive ℓ-th root of unity $\zeta\in k$. Let G denote the simple, simply-connected algebraic group over k with root system Φ. The Frobenius–Lusztig kernel u_ζ is a finite-dimensional Hopf subalgebra of U_ζ. The structure of the cohomology ring $H^\bullet(u_\zeta,k)$ has been well-studied in the case $k=\mathbb{C}$, but results on the structure of $H^\bullet(u_\zeta,k)$ when k has positive characteristic (the so-called mixed case) are absent from the literature. In this talk we will discuss the structure of $H^\bullet(u_\zeta,k)$ under the assumption that k has positive characteristic. We will also discuss the cohomology rings of certain other finite-dimensional subalgebras of U_ζ corresponding to higher Frobenius kernels of G. (Received September 15, 2008)

1046-20-1321 **Josh Roberts*** (jroberts@ms.uky.edu), Department of Mathematics, 719 Patterson Office Tower, University of Kentucky, Lexington, KY 40506-0027. *On an algorithm for low dimensional group homology.* Preliminary report.

Given a finitely presented group G, Hopf's formula expresses the second integral homology of G in terms of its generators and relators. We give an algorithm that exploits Hopf's formula to compute (or at least estimate) $H_2(G)$ with coefficients in a finite field, and give an example using SL_2 of a specific ring of integers. This example is related to a conjecture of Quillen. (Received September 15, 2008)

1046-20-1336 **Oliver Ruff*** (oliver.ruff@gmail.com), Department of Mathematics, 2801 W Bancroft Street, University of Toledo, Toledo, OH 43606. *Centers of cyclotomic Sergeev superalgebras.*

The affine Sergeev superalgebra, introduced by Nazarov, is the twisted analogue of the degenerate affine Hecke algebra. Associated to it there is a family of finite-dimensional quotients called the *cyclotomic Sergeev superalgebras*, obtained by factoring out a polynomial expression of degree l in one of its generators. (This is analogous to the description of the group algebra of the symmetric group as a quotient of the degenerate affine Hecke algebra.) These algebras play an important role in the spin representation theory of the symmetric group.

We present an explicit description of the even centers of the cyclotomic Sergeev superalgebras in the case when the parameter l is odd, and thereby classify their blocks. Our approach is a generalization of the method recently used by Brundan to describe the centers of the degenerate cyclotomic Hecke algebras. (Received September 15, 2008)

1046-20-1504 **Luise-Charlotte Kappe** (menger@math.binghamton.edu), Department of Mathematical Sciences, State University of New York at Binghamton, Binghamton, NY 13902-6000, and **Joanne L Redden*** (mathprofessor@mac.com), Department of Mathematics, Elmira College, One Park Place, Elmira, 14901. *On the Covering Number of Small Alternating Groups.*

According to Bernhard Neuman, every group with a noncyclic finite homomorphic image is the union of finitely many proper subgroups. The minimal number of subgroups needed to cover a group G is called the covering number of G, denoted by $\sigma(G)$. Tomkinson showed that for a solvable group $\sigma(G) = p^\alpha$ where p^α is the order of a particular chief factor of G and he suggested investigation of $\sigma(G)$ for families of finite simple groups. So far, a few results are known, among them some for alternating groups. Cohn showed that $\sigma(A_5) = 10$ and by a result of Maróti $\sigma(A_n) \leq 2^{n-2}$, provided $n \neq 7$ or 9, and equality holds for n even with $n \equiv 2 \mod 4$. Thus, $\sigma(A_6) = 16$ and $\sigma(A_{10}) = 256$. We show that $\sigma(A_7) = 31$ and with the help of GAP improve on Maróti's estimates for $\sigma(A_8)$ and $\sigma(A_9)$. (Received September 15, 2008)

1046-20-1670 **Margaret H. Dean*** (mdean@bmcc.cuny.edu), BMCC Mathematics Department, 199 Chambers Street, N 524, New York, NY 10007, **Marcos Zyman** (mzyman@bmcc.cuny.edu), BMCC Mathematics Department, 199 Chambers St., N 528, New York, NY 10007, and **Katalin A. Bencsáth** (katalin.bencsath@manhattan.edu), Department of Mahtematics, Manhattan College, Riverdale, NY 10471. *IA-automorphisms of center by metabelian groups.* Preliminary report.

The IA-group of G is a subgroup of $AutG$ consisting of those automorphisms that induce the identity modulo the derived group. We study the structure of the IA-automorphisms of certain groups which are metabelian extensions of their centers. We also discuss the existence of a finitely generated center by metabelian group whose IA-group is not finitely generated. Wreath products play a major role in this discussion. (Received September 16, 2008)

1046-20-1762 **Hendryk Pfeiffer*** (pfeiffer@math.ubc.ca), Department of Mathematics, The University of British Columbia, 121-1984 Mathematics Road, Vancouver, BC V6T 1Z2, Canada. *Every modular category is the category of modules over an algebra.*

How do you categorify a modular category? Some modular categories can be obtained from quantum groups $U_q(\mathfrak{g})$, q a suitable root of unity, by studying the category of tilting modules and by taking its quotient modulo the 'negligible' morphisms. This approach has two drawbacks. First, not every modular category is known to be of this form. Second, the construction is technically difficult and not very transparent because it involves a quotient of the category of tilting modules.

I show how *every* modular category can be obtained as the category of modules over an algebra with extra strucure. There is no need for any quotient. I also explain how the combinatorial 3-manifold invariants can be rephrased in the language of these algebras. (Received September 16, 2008)

1046-20-1844 **Florian L Deloup*** (florian.deloup@math.univ-toulouse.fr), Institut de Mathématiques, Université de Toulouse III, 31062 Toulouse, France. *Palindromes and orderings in Artin groups.*

The braid group B_n, endowed with Artin's presentation, admits one distinguished involution, the anti-automorphism rev : $B_n \to B_n$, $v \mapsto \bar{v}$, defined by reading braids in the reverse order (from right to left instead of left to right). More generally, this involution is defined for all Artin groups. Elements invariant under this involution are palindromes. We study palindromes in Artin groups of finite type using orderings. In particular, we show that "pure palindromes can always be cut into halves". (Received September 16, 2008)

1046-20-1928 **Mladen Bestvina**, **Thomas Church*** (tchurch@math.uchicago.edu) and **Juan Souto**. *The point-pushing subgroup of the punctured mapping class group is not realizable by diffeomorphisms.*

The mapping class group of a surface Σ with one marked point z fits into the short exact sequence

$$1 \to \pi_1(\Sigma, z) \to \mathrm{Map}(\Sigma, z) \to \mathrm{Map}(\Sigma) \to 1.$$

The kernel is known as the point-pushing subgroup, since its elements are obtained by "pushing" the marked point along loops in the fundamental group of Σ. By using Milnor's inequality for the Euler number of a flat vector bundle over a surface, we show that the point-pushing subgroup cannot be realized by diffeomorphisms of Σ fixing z. (Received September 16, 2008)

1046-20-1948 **Alexei Miasnikov*** (alexeim@math.mcgill.ca), Department of Mathematics and Statistics, 805 Sherbrooke St. West, Montreal, Quebec H3A 2K6, Canada. *Mathematics of Commutator Key Exchange.* Preliminary report.

This talk is about some recent developments in non-commutative cryptography. The main focus will be on mathematical problems that arise here, and how solutions to these problems may affect security of various public key exchange schemes. I will discuss on how the classical algebraic algorithmic problems may be used in cryptography, and what should be avoided; why undecidable decision problems may play a part in cryptanalysis of real cryptosystems, and what kind of practical knowledge one can get from asymptotic methods. Most of the ideas that occur here are quite general, but I will try to explain them on one particular example - the commutator key exchange schemes based on groups. The talk is based on joint work with R.Gilman, A.Myasnikov, and A.Ushakov. (Received September 16, 2008)

1046-20-2055 **Stephen M Gagola III*** (sgagola@math.arizona.edu), Department of Mathematics, The University of Arizona, 617 N. Santa Rita Ave, Tucson, AZ 85721. *The development of Sylow p-subloops in finite Moufang loops.*

The split octonion algebras are always nonassociative but do satisfy a weak form of the associative law, namely the Moufang identity. A Moufang loop is a generalization of a group that satisfies the Moufang identity. All finite nonassociative simple Moufang loops are Paige loops, namely, the set of unit norm split-octonions modulo the center. We prove that if L is a finite Moufang loop and p is a "Sylow prime" for L then every p-subloop of L is contained in a Sylow p-subloop of L. Here p is a Sylow prime for L if $p \nmid \frac{q^2+1}{gcd(q+1,2)}$ for all q for which a composition factor of L is isomorphic to the Paige loop $P(q)$. (Received September 16, 2008)

22 ► Topological groups, Lie groups

1046-22-148 **Andrei Rapinchuk*** (asr3x@virginia.edu), Department of Mathematics, University of Virginia, Kerchof Hall, P.O. Box 400137, Charlottesville, VA VA 22904. *Weakly commensurable arithmetic groups, with applications to locally symmetric spaces.*

I will present a recent joint work with Gopal Prasad in which we introduced and analyzed a new notion of weak commensurability of Zariski-dense subgroups. The most definitive results are available for S-arithmetic subgroups: it turns out that in many situations, weak commensurability of S-arithmetic subgroups implies their commensurability, and in all cases, the subgroups weakly commensurable to a given S-arithmetic subgroups split into finitely many commensurability classes. These results have important consequences for the well-known problem in differential geometry of analyzing lengths-commensurable and isospectral Riemannian manifolds. In particular, using our results we are able to answer Marc Kac's famous question "Can one hear the shape of a drum?" for compact arithmetically defined locally symmetric spaces. (Received August 06, 2008)

1046-22-263 **jennifer d berg*** (berg.jennifer@gmail.com), 14 winter street, no.1, leominster, MA 01453. *On the Casimir fields of* $q(n)^{(1)}$. Preliminary report.

The goal of the project introduced here is to investigate the properties of the "Casimir fields" of the Lie superalgebra $q(n)$, that is the vertex operators obtained from applying the state fields correspondence to the generators of the center of $\mathcal{U}(q(n))$. Connecting the calculations to Feynman diagrams opens the door to techniques which may be used to verify that all the "Casimir fields" are, in fact central. (Received August 24, 2008)

1046-22-272 **Steven Glenn Jackson** (jackson@math.umb.edu) and **Alfred G. Noël*** (anoel@math.umb.edu), University of Massachusetts Boston, Mathematics Department, 100 Morrissey boulevard, Boston, MA 02125-3393. *Nilpotent Orbits Associated to Coxeter Cells.*

Let $\mathfrak{g}$ be a complex reductive Lie group with adjoint group G and Weyl group W. This paper describes a simple algorithm by which one can read off the complex nilpotent orbit associated with a cell representation of W—provided that W is of classical type.

The τ-signature of a cell representation $\mathcal{C}$ coincides with that of its unique special subrepresentation, and also with the collection of all parabolics $\mathcal{P}$ such that the simple roots of $\mathcal{P}$ are contained in some τ-invariant of the cell. Combining this with the Springer correspondence, we obtain a simple method which computes the nilpotent orbit associated with the cell directly from the τ-invariants.

In principle, these algorithms could be implemented as a package of the *Atlas of Lie groups and representations* software developed by Fokko du Cloux and Marc van Leeuwen. Several examples will be given using this software. (Received August 25, 2008)

1046-22-334 **Firas Y Hindeleh*** (hindelef@gvsu.edu), 1 Campus Dr., Allendale, MI 49401, and **Gerard Thompson** (gthomps@utoledo.edu), 2801 W Bancroft St., Toledo, OH 43606. *Seven dimensional Lie algebras with a four-dimensional nilradical.* Preliminary report.

We classify seven dimensional Lie algebras that have a four-dimensional nilradical. It is shown that any such indecomposable algebra necessarily has an abelian nilradical. Accordingly the classification reduces to the problem of classifying three-dimensional pencils of four by four matrices with the property that no linear combination of the generators is nilpotent. We enumerate eight matrix Lie groups whose Lie algebras comprise the collection of seven-dimensional abelian nilradical algebras. In each case we list also a set of right-invariant vector fields, geodesic equations of the corresponding canonical connection and a Lagrangian that engenders the geodesics as Euler-Lagrange equations. (Received August 26, 2008)

1046-22-1130 **Lisa Carbone** and **Leigh Cobbs*** (cobbs@math.rutgers.edu). *Infinite Towers of Cocompact Lattices in Kac-Moody Groups.* Preliminary report.

Let G be a locally compact Kac-Moody group of affine or hyperbolic type over a finite field $\mathbb{F}_2$. We suppose that G has type ∞, that is, the Weyl group W of G is a free product of $\mathbb{Z}/2\mathbb{Z}$'s. This includes all rank 2 and two possible rank 3 Kac-Moody groups. We show that if $rank(G) = 2$ then G contains an infinite tower of non-conjugate cocompact lattices $\ldots \Gamma_3 \leq \Gamma_2 \leq \Gamma_1 \leq \Gamma$, and we characterize the quotient graphs of groups $\Gamma_i \backslash\backslash X$. We also give sufficient conditions for extending coverings of edge-indexed graphs to covering morphisms of graphs of groups and we show how this gives rise to other infinite families of cocompact lattices in G. When $rank(G) = 3$ we exhibit a subgroup $\mathcal{Q}$ which contains a cocompact lattice Λ acting discretely and cocompactly on a simplicial tree $\mathcal{X}$. We exhibit an infinite tower of cocompact lattices $\ldots \Lambda_3 \leq \Lambda_2 \leq \Lambda_1 \leq \Lambda$ in $\mathcal{Q}$ whose images in G are also discrete. This induces a tower of non-discrete subgroups $\ldots \Lambda_3' \leq \Lambda_2' \leq \Lambda_1' \leq \Lambda$ in G for which we can characterize the quotient complexes of groups. (Received September 14, 2008)

1046-22-1233 **Benjamin F Jones*** (bjones@math.uga.edu), 434 Meigs St, Athens, GA 30601. *Normality of Enhanced Nilpotent Orbit Closures.* Preliminary report.

We discuss preliminary results of joint work with Achar and Henderson on the normality of $GL(V)$ orbit closures in $N \times V$, where N is the variety of nilpotent endomorphisms of V. These "Enhanced Nilpotent Orbits" have been studied previously by Achar and Henderson. Their geometry is closely related to the geometry of the "Exotic Nilpotent Orbits" defined by S. Kato and studied in connection with the representation theory of affine Hecke algebras with unequal parameters in types B and C. (Received September 15, 2008)

1046-22-1303 **Ilir Snopce*** (snopce@math.binghamton.edu), 191 Main St. Apt 3R, Binghamton, NY 13905. *Pro-p groups of rank 3 and the question of Iwasawa.*

For a finitely generated pro-p group G let $d(G)$ denote the minimal number of topological generators of G. For a positive integer n , Iwasawa raised the question of determining all pro-p groups G which satisfy the following condition:

$$d(H) - n = [G : H](d(G) - n)$$

for all open subgroups H of G.
In this talk we consider the case $n = 3$. (Received September 15, 2008)

1046-22-1343 **Amir A. Maleki*** (amaleki@howard.edu), 20892 Butterwood Falls Terrace, Sterling, VA 20165. *Caratheodory Approch in Haar Measure.* Preliminary report.

Let Y be the space of all functions from the set of natural numbers to the set 0, 2.Then Y is a compact topological group.Using Caratheodory approch we construct Haar Measure on Y. (Received September 15, 2008)

1046-22-1366 **Vladimir Chernousov**, **Lucy Lifschitz** and **Dave Witte Morris*** (Dave.Morris@uleth.ca), Department of Mathematics & Computer Science, University of Lethbridge, Lethbridge, Alberta T1K 3M4, Canada. *Locally symmetric subspaces of locally symmetric spaces.*

It has long been known that only two manifolds are minimal in the category of symmetric spaces $X = G/K$ of rank greater than 1. (We assume G is a connected, semisimple Lie group with no compact factors.) Namely, every symmetric space in this category contains either the product of two hyperbolic planes or the symmetric space associated to $\mathrm{SL}(3,\mathbb{R})$. The corresponding problem for noncompact spaces of finite volume that are locally symmetric, rather than symmmetric, also has a fairly simple answer, even though infinitely many manifolds are minimal in this category. The proof goes through a case-by-case analysis of the possible $\mathbb{Q}$-forms of G. The compact case will have a more complicated answer, and remains open. (Received September 15, 2008)

1046-22-1525 **Robyn Brooks**, **Derek Habermas** and **Karol Koziol*** (karolkoziol@nyu.edu), 245 Tennyson Ave, Syracuse, NY 13204, and **Kirsten Trickey**. *Decompositions of Various Compact Symmetric Spaces.*

Cartan demonstrated that it is possible to embed a symmetric space isometrically into a Lie group. Thus, by intersecting the image of a symmetric space with the Birkhoff decomposition of the Lie group, we arrive at a decomposition of the space into levels, indexed by elements of the Weyl group. We examine this decomposition for various compact symmetric spaces, and provide criteria for the existence of non-empty levels. (Received September 15, 2008)

1046-22-1766 **Phoebe Ho McLaughlin*** (pmclaughlin@ucmo.edu), University of Central Missouri, Department of Math and Computer Science, WCM 227, Warrensburg, MO 64093, **Shing S. So**, University of Central Missouri, Department of Math & Computer Science, WCM 205A, Warrensburg, MO 64093, and **Haohao Wang**, Southeast Missouri State University, Department of Mathematics, MS6700, One University Plaza, Cape Girardeau, MO 63701. *On Maximal Ideals of Compact Connected Mobs.* Preliminary report.

In a compact mob S, some studies have been done on ideals of S under the condition $S^2 = S$. In this paper, we further investgate the connection between the structure of ideals, especially maximal ideals, of a compact connected mob S and the conditions of $S^2 = S$ and $S^2 \neq S$. (Received September 16, 2008)

1046-22-1865 **Stavros Papadakis** and **Bart Van Steirteghem***, Department of Mathematics, Medgar Evers College (CUNY), 1650 Bedford Avenue, Brooklyn, NY 11225. *Equivariant degenerations of spherical modules for groups of type* A. Preliminary report.

Let G be connected reductive algebraic group over $\mathbb{C}$, fix a Borel subgroup B of G and a maximal torus T in B, and let U be the unipotent radical of B. Let Y be an affine toric variety for T. Alexeev and Brion introduced a moduli scheme M_Y which classifies affine (spherical) G-varieties X equipped with a T-equivariant isomorphism $X//U \to Y$, where $X//U = \mathrm{Spec}(\mathbb{C}[X]^U)$.

S. Jansou, P. Bravi and S. Cupit-Foutou described the first examples of M_Y. We studied the case where $Y = W//U$ with W a spherical G-module and G of type A (a spherical G-module W is a representation W of G which is *spherical* as a G-variety, that is, which contains a dense B-orbit). (Received September 16, 2008)

1046-22-1994 **Jon W. Short*** (jon@shsu.edu), Mathematics and Statistics, Box 2206, Sam Houston State University, Huntsville, TX 77341, and **T. Christine Stevens** (stevensc@slu.edu), Dept. of Mathematics and Computer Science, Saint Louis Univ, Ritter Hall 104, 220 N. Grand Blvd, St. Louis, MO 63103. *Topologies that are defined by forcing sequences of real numbers to converge to zero.* Preliminary report.

We consider metrizable topologies for the real numbers $\mathbb{R}$ that are defined by choosing a non-decreasing sequence of positive real numbers and specifying a rate at which that sequence will converge to zero. The resulting topologies are always weaker than the usual topology for $\mathbb{R}$. Building upon a previous paper [*Weakened Lie groups and their locally isometric completions*, Topology Appl. 135 (2004), 47-61], we show that very different sequences will yield topologies that are locally isometric, provided the "rate sequence" is the same. Since the local isometry is not, in general, a local homomorphism, the resulting topologies can have different global properties, which we investigate. Our results have applications in the study of Lie groups of transformations, which involves the investigation of topologies for Lie groups that are weaker than the usual topology. (Received September 17, 2008)

26 ► Real functions

1046-26-654 **Nasser Dastrange*** (dastrange@bvu.edu), Buena Vista University, 610, W. 4th. St., Storm Lake, IA 50588. *A generalization of the mean value theorem for integrals.* Preliminary report.

An important theorem in calculus is the integral mean value theorem. In this talk we introduce a generalization of this theorem. Furthermore, we investigate the nature of the integral representations of some well known means such as arithmetic, geometric, and logarithmic.

Additionally, some interesting properties, examples, geometrical illustrations, and recent research on the integral mean value theorem will be presented. (Received September 09, 2008)

1046-26-1265 **Peter R Mercer*** (mercerpr@math.buffalostate.edu), Dept. Mathematics, Buffalo State College, 1300 Elmwood Avenue, Buffalo, NY 14222. *Error terms for Steffensen's, Young's, and Chebychev's Inequalities.*

We recast the well-known Steffensen's inequality, and a number of its relations, as an equality involving an error term. The same general idea leads to error terms for Young's and Chebychev's inequalities. (Received September 15, 2008)

1046-26-1499 **Kandasamy Muthuvel*** (muthuvel@uwosh.edu), Department of Mathematics, University of Wisconsin-Oshkosh, Oshkosh, WI 54901. *Iterations of Darboux Functions.*

In this paper, we study Darboux function f satisfying the property that there exists a continuous function g that is nonconstant on every nonempty open interval and for every real number x, $f^n(x) = g(x)$ for some positive integer n. We recently proved in a paper that if the set of all such n is bounded, then f is continuous. In this talk, we give an example to show that the above conclusion is not true if the condition "the set of all such n is bounded" is dropped. However, if g is the identity function, then f is continuous and, either f is the identity function or $f = f^{-1}$. (Received September 15, 2008)

28 ► Measure and integration

1046-28-119 **Konrad J Swanepoel*** (konrad.swanepoel@gmail.com), Faculty of Mathematics, Chemnitz University of Technology, 09107 Chemnitz, Germany. *Outer linear measure of connected sets via Steiner trees.*

We give a definition of the length of a connected set in a metric space in terms of Steiner trees on its finite subsets. We show that this length coincides with the outer linear measure of Carathéodory (also known as 1-dimensional Hausdorff measure) restricted to connected sets. This approach yields simple proofs of theorems of Gołąb, Bógnar and Fremlin, and answers an old question of Menger on the definition of arc length. The proofs employ, apart from a modicum of graph theory, only elementary properties of connectedness, and no measure theory apart from the definition of outer linear measure. (Received July 28, 2008)

1046-28-414 **Matthew D Foreman*** (mforeman@math.uci.edu), Mathematics Department, UC Irvine, Irvine, CA 92697. *Models for measure preserving transformations.*

There are several models for the collection of measure preserving transformations and the collection of ergodic measure preserving transformations. In joint work with Dan Rudolph and Benjamin Weiss, we show that these models are equivalent in the sense that there are bijections that preserve category for "dynamical properties".

A new model for the ergodic transformations is introduced, the "rational invariant measures". This is shown to be universal and open problems about the new model are discussed. (Received September 01, 2008)

1046-28-670 **Seung Jun Chang**, **Hyun Soo Chung** and **David Skoug*** (dskoug@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588-0130. *Convolution Products, Integral Transforms and Inverse Integral Transforms of Functionals in $L_2(C_0[0,T])$.*

In this paper we establish several very basic formulas relating convolution products, integral transforms and inverse integral transforms for functionals in $L_2(C_0[0,T])$. The expansion of functionals in $L_2(C_0[0,T])$ in terms of Fourier-Hermite functionals plays a key role. (Received September 09, 2008)

1046-28-1563 **Mark Burgin** (mburgin@ucla.math.edu), **Dongxin (Tony) Chen*** and **Alan Krinik** (ackrinik@csupomona.edu), Alan Krinik, Department of Mathematics and Statistics, 3801 W. Temple Avenue, Pomona, CA 91768. *Radon-Nikodym Theorem for Hyper-measures.*

To expand the domain of integrable functions, hyper-integration was introduced and studied. Hyper-integration is based upon an application of hyper-measures (Burgin, M., Hyper-measures in General Spaces, International J. of Pure and Applied Mathematics, v. 24, No. 3, 2005, pp. 299-323) which, in turn, depends upon the extension of real numbers to hyper-numbers, see, for example, Burgin, M., Theory of Hyper-numbers and Extra-functions, Functional Spaces and Differentiation, Discrete Dynamics in Nature and Science, Vol. 7, (3), 2002, pp. 201-212.

In this talk, we extend the classical Radon-Nikodym Theorem to the hyper-measure setting. The derivation, whenever possible, parallels the analysis of Anton R. Schep's article found in the American Mathematical Monthly, Vol. 110, No. 6,June-July 2003, pp. 536-538. Consequences of this generalization are discussed as time allows. (Received September 16, 2008)

30 ► Functions of a complex variable

1046-30-113 **Michael Dorff*** (mdorff@math.byu.edu), Department of Mathematics, Brigham Young University, Provo, UT 84602, and **Magdalena Woloszkiewicz**. *Convex combinations of harmonic mappings.*

Complex-valued harmonic mappings can be regarded as generalizations of analytic functions. We are interested in investigating univalent harmonic mappings. These are connected with minimal surfaces in $\mathbb{R}^3$. In this paper, we prove results concerning the univalence of the linear combinations of harmonic mappings. One application of these results offers an easy way to construct harmonic mappings onto nonconvex polygonal domains and to construct the corresponding minimal graphs over these nonconvex domains. This results in a new family of minimal surfaces that are generalizations of the Jenkins-Serre surfaces. (Received July 24, 2008)

1046-30-133 **Rosihan M. Ali*** (rosihan@cs.usm.my), School of Mathematical Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia. *On Analytic Multivalent Functions.* Preliminary report.

Let $\mathcal{A}_p$ be the class of all p-valent analytic functions $f(z) = z^p + a_{p+1}z^{p+1} + a_{p+2}z^{p+2} + \cdots$ in the open unit disk $\Delta = \{z \in \mathbb{C} : |z| < 1\}$. Subclasses of p-valent starlike and convex functions in the unit disk in the complex plane will be discussed. It is shown that every p-valent convex function is starlike. Subordination properties, as well as convolution results with prestarlike functions are obtained for these classes.

Additionally several interesting subordination results and best dominants are obtained for higher-order derivatives of p-valent functions.

Subordination results and best dominants are also determined on the *Dziok-Srivastava* linear operator

$$H_p^{(l,m)}(\alpha_1, \ldots, \alpha_l; \beta_1, \ldots, \beta_m) : \mathcal{A}_p \to \mathcal{A}_p$$

defined by the convolution

$$\begin{aligned} H_p^{(l,m)}(\alpha_1, \ldots, \alpha_l; \beta_1, \ldots, \beta_m)f(z) &:= h_p(\alpha_1, \ldots, \alpha_l; \beta_1, \ldots, \beta_m; z) * f(z) \\ &= z^p + \sum_{n=p+1}^{\infty} \frac{(\alpha_1)_{n-p} \ldots (\alpha_l)_{n-p}}{(\beta_1)_{n-p} \ldots (\beta_m)_{n-p}} \frac{a_n z^n}{(n-p)!}. \end{aligned}$$

These results are next applied to yield as special cases various known results. (Received August 01, 2008)

1046-30-134 **Peter Ebenfelt** (pebenfel@ucsd.edu), Department of Mathematics, University of California, San Diego, La Jolla, CA 92093-0112, **Dima Khavinson*** (dkhavins@cas.usf.edu), Department of Mathematics, University of South Florida, Tampa, FL 33620, and **Harold S. Shapiro** (shapiro@math.kth.se), Department of Mathematics, Royal Institute of Technology, S-10044 Stockholm, Sweden. *"Fingerprints" of the Two Dimensional Shapes and Lemniscates.* Preliminary report.

The newly emerging field of vision and pattern recognition often focuses on the study of two dimensional "shapes", i.e. simple, closed smooth curves. A common approach to describing shapes consists in defining a "natural" embedding of the space of curves into a metric space and studying the mathematical structure of the latter. Another idea that has been pioneered by Kirillov and developed recently among others by Mumford and Sharon consists of representing each shape by its "fingerprint", a diffeomorphism of the unit circle. Kirillov's theorem states that the correspondence between shapes and fingerprints is a bijection modulo conformal automorphisms of the disk. In this talk we discuss the recent joint work with P. Ebenfelt and Harold S. Shapiro outlining an alternative interpretation of the problem of shapes and Kirillov's theorem based on finding a set of natural and simple fingerprints that is dense in the space of all diffeomorphisms of the unit circle. This approach is inspired by the celebrated theorem of Hilbert regarding approximation of smooth curves by lemniscates. We shall outline proofs of the main results and discuss some interesting function-theoretic ramifications and open questions regarding possibilities of numerical applications of this idea. (Received August 01, 2008)

1046-30-145 **Abebaw Tadesse*** (atadesse@lunet.edu), Department Of Mathematics, JH 305, Langston University, Langston, OK 73050. *Chracterizing Compact Composition Operators on the Hardy-Simirnov Spaces.* Preliminary report.

In this talk, we characterize compact composition operators on the Hardy-Smirnov Spaces. We also give an example verifying the results for a simple, but non-trivial, geometry where an explicit expression for the Riemann map is known.

(Received August 06, 2008)

1046-30-187 **Erin Rita Militzer*** (militzer@ms.uky.edu), 430 Redding Road, Apt #1806, Lexington, KY 40517. *L^p - Bounded Point Evaluations and Uniform Rational Approximation.* Preliminary report.

In 1991, J.E. Thompson determined completely the structure of $H^2(\mu)$, the closed subspace of $L^2(\mu)$ that is spanned by the polynomials, whenever μ is a compactly supported measure in the complex plane. In 2006, J.E. Brennan proved Thomson's main theorem using Tolsa's work on the semiadditivity of analytic capacity. We apply the techniques used from the latter proof to answer a question posed in 1973 by Brennan which is the following: Does there exist a compact set E such that $H^p(E, dA) = L^p(E, dA)$ for every p, but $R(E) \neq C(E)$? Here $C(E)$ is the space of continuous functions on E and $R(E)$ the uniform closure of the rational functions with poles off E. We answer this question in the negative. (Received August 14, 2008)

1046-30-320 **Alexei Poltoratski*** (alexeip@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843. *Toeplitz kernels and Polya sets.*

A classical lemma by Polya states that any entire function of exponential type zero bounded on the set of integers is a constant. In his 1940 book N. Levinson posed a natural question asking what sets can replace the set of integers in Polya's lemma. Many deep results in this direction were obtained sinse then, including those by N. Levinson, B. Levin and L. De Branges.

In my talk I will present a solution to the Polya-Levinson problem obtained using the method of Toeplitz kernels. This method was recently developed in our joint project with N. Makarov. It allows one to treat several related problems of classical analysis, such as sampling/uniqueness problems in spaces of analytic functions, spectral problems for second order differential operators, completeness problems for special functions, etc. The main new results presented in this talk were obtained jointly with my student M. Mitkovski. (Received August 26, 2008)

1046-30-350 **Ken Stephenson*** (kens@math.utk.edu), **Elias Wegert** and **David Bauer**. *discrete conformal flows in circle packing.* Preliminary report.

A **discrete analytic function** $f : Q \to P$ is a mapping between circle packings which preserves tangency and orientation. The circles manifest a given pattern of tangencies, an abstract combinatorial structure K, and packings Q and P each endow K with a geometric structure. As a geometric mapping, f turns out to be intrinsically 'conformal' in nature, hence our interest in circle packings.

For a fixed combinatorial pattern K, the collection $\mathcal{F} = \mathcal{F}_K$ of locally univalent circle packings for K is a discrete model for the collection of locally univalent analytic functions on the unit disc. We realize $\mathcal{F}$ as a smooth variety $\mathcal{V} \subset \mathcal{R}^N$ and discuss parameterized curves in $\mathcal{V}$. These curves represent a form of "curvature flow". Examples of discrete curvature flow will be shown with a view to their classical analogues. (Received August 27, 2008)

1046-30-351 **John R. Akeroyd*** (akeroyd@uark.edu), Science-Engineering, room 347, Mathematics Department, University of Arkansas, Fayetteville, AR 72701. *Examples in Bergman and Hardy Spaces.*

We examine density of the polynomials in $\mathbb{A}^t(G)$ and $H^t(G)$ (i.e., the Bergman and Hardy spaces) of some rather exotic, bounded regions G in the complex plane. In some cases, density varies with t. Applications and open questions are also discussed. (Received August 27, 2008)

1046-30-457 **Alexander L Volberg*** (volberg@math.msu.edu), Dept. of Math., Michigan State Univ., East Lansing, MI 48823, and **Peter Yuditskii** (yuditskii@math.msu.edu), Dept. Math., Michigan State Univ., East lansing, MI 48823. *Nehari's problem and matrix A_2. Alexander Volberg and Peter Yuditskii.*

We consider Nehari's problem in the case of non-uniqueness of solution. The solution set is then parametrized by the unit ball of H^∞ by means of so-called *regular generators* — bounded holomorphic functions ϕ. The definition of *regularity* is given below, but let us mention now that 1) the following assumption on modulus of ϕ is sufficient for *regularity*: $\frac{1}{1-|\phi|^2} \in L^1(\mathbb{T})$; 2) there is no necessary and sufficient condition of *regularity* on bounded holomorphic ϕ in terms of $|\phi|$ on $\mathbb{T}$, this is the result of A. Kheifits. This makes reasonable the attempt to find a weaker sufficient condition on $|\phi|$ than the condition in 1). This is done here. Also we are discussing certain new necessary and sufficient conditions of *regularity* in terms of bounded mean (weighted) oscillations of ϕ. They involve the matrix A_2 condition of Treil-Volberg. (Received September 03, 2008)

1046-30-494 **Paul A. Gunsul***, Mathematical Sciences, Watson Hall, DeKalb, IL 60115. *An Identical Function Theorem for Functions of Slow Growth in the Disk.* Preliminary report.

R. Nevanlinna showed that if two non-constant, meromorphic functions in the plane agree for five distinct values, then the two functions are identical. This result carries over for admissible functions in the unit disk since the error term in the Second Fundamental Theorem of Nevanlinna Theory is small relative to the growth of such functions. But for functions in class $\mathcal{F} = \left\{ f : \limsup_{r\to 1} \frac{T(r,f)}{-\log(1-r)=\alpha(f)<\infty} \right\}$, the error term for the Second Fundamental Theorem may be of similar magnitude to the growth of the function. Using a result from work of D.F. Shea and L.R. Sons for functions in class $\mathcal{F}$, we show how many distinct values of agreement two meromorphic functions in class $\mathcal{F}$ with $\alpha(f) > 0$ need to have in order to be identical. (Received September 04, 2008)

1046-30-565 **Tamas Forgacs** (tforgacs@csufresno.edu), Department of Mathematics, 5245 North Backer Avenue M/S PB108, Fresno, CA 93740, and **Andrzej Piotrowski*** (apiotrowski@uas.alaska.edu), Soboleff Building, Mailstop: SOB1, 11120 Glacier Hwy, Juneau, AK 99801. *Multiplier Sequences for Generalized Laguerre Bases.* Preliminary report.

This paper investigates necessary and sufficient conditions under which a real sequence $\gamma_0, \gamma_1, \gamma_2, \ldots$ has the following property: If the real polynomial $\sum_{k=0}^n a_k L_k^{(\alpha)}(x)$ has only real zeros, then the polynomial $\sum_{k=0}^n \gamma_k a_k L_k^{(\alpha)}(x)$ also has only real zeros, where $L_k^{(\alpha)}(x)$ is the k^{th} generalized Laguerre polynomial given by the relation $k!L_k^{(\alpha)}(x) := x^{-\alpha}e^x D^k(e^{-x}x^{k+\alpha})$. (Received September 08, 2008)

1046-30-651 **Erwin Miña-Díaz*** (minadiaz@olemiss.edu), The University of Mississippi, Department of Mathematics, Hume Hall 305, P. O. Box 1848, University, MS 38677-1848, and **Peter Dragnev**. *Asymptotics of polynomials orthogonal over planar regions with analytic boundary.* Preliminary report.

Let L be an analytic Jordan curve in the complex plane $\mathbb{C}$. Polynomials that are orthonormal with respect to area measure over the interior domain of L were first considered by Carleman, who established a strong asymptotic formula for the polynomials valid on some neighborhood of the closed exterior of L. We extend the validity of Carleman's asymptotic formula to a maximal open set, every boundary point of which is an accumulation point of the zeros of the polynomials. The results will be illustrated with some concrete examples and numerical computations. (Received September 09, 2008)

1046-30-653 **Alexandru Aleman**, **Peter L. Duren** and **Maria J. Martin*** (mariajma@umich.edu), Department of Mathematics, University of Michigan, Ann Arbor, MI 48109, and **Dragan Vukotic**. *Multiplicative isometries and isometric zero-divisors.*

A key result in the theory of Hardy spaces is the classical theorem of F. Riesz that the Blaschke products serve as isometric zero-divisors. More recently, it was shown that the Bergman space A^p has no isometric zero-divisors. The proof consisted of producing contractive zero-divisors of unit norm, proving their uniqueness up to rotation, and showing that they are not isometric.

We will give a much simpler proof that the Bergman spaces have no isometric zero-divisors. This is deduced from the easily proved fact that the only isometric pointwise multipliers of A^p are the unimodular constants. The same approach is applied to the Bloch space, the Dirichlet space, and more general spaces with weighted integral norms. It is shown that none of those spaces admit isometric zero-divisors. (Received September 16, 2008)

1046-30-681 **Ngin-Tee Koh*** (nkoh@uiuc.edu), Dept. of Mathematics, Univ. of Illinois, 1409 W. Green St, Urbana, IL 61801. *Approximable Quasidisks.*

We discuss a question posed by Anderson and Hinkkanen: what quasidisks are approximable? We show that a quasidisk bounded by an analytic curve is approximable. (Received September 10, 2008)

1046-30-882 **Ross Flek** and **Linda Keen*** (linda.keen@lehman.cuny.edu), Dept of Math and Computer Science, Lehman College CUNY, Bedford Park Blvd, Bronx, NY 10468. *Boundaries of Bounded Fatou Components of Quadratic Maps.*

In this talk we characterize those external rays that land on the bounded Fatou components of hyperbolic and parabolic quadratic maps. For those maps not in the main cardioid of the Mandelbrot set, we prove that these rays form a Cantor subset of the circle at infinity. Our techniques involve both the orbit portraits of Goldberg and Milnor that relate the dynamic and parameter planes and the Thurston theory of laminations for quadratic maps. This classification is important since it provides a way to characterize buried Julia sets of a class of degree two rational maps which are conjugate to self-matings of the above quadratics. (Received September 12, 2008)

1046-30-912 **Stacey Muir*** (muellers2@scranton.edu), University of Scranton, Department of Mathematics, Scranton, PA 18510. *Weak Subordination for Convex Univalent Harmonic Functions.*

For two complex-valued harmonic functions f and F defined in the open unit disk Δ with $f(0) = F(0) = 0$, we say f is weakly subordinate to F if $f(\Delta) \subset F(\Delta)$. We will define a weak subordination chain of harmonic functions and present the construction of a weak subordination chain of convex univalent harmonic functions using a harmonic de la Vallée Poussin mean. (Received September 12, 2008)

1046-30-946 **Kari Fowler*** (kfowler@ut.edu), The University of Tampa, 401 W. Kennedy Blvd., Tampa, FL 33606, and **Linda Sons** (sons@math.niu.edu), Northern Illinois University, DeKalb, IL 60115. *The MacLane Class and Complex Differential Equations in the Unit Disk.* Preliminary report.

The MacLane class consists of nonconstant analytic functions f with asymptotic values at each point of a set of points $A \subset C = \{z : |z| = 1\}$ with A dense on C. Research concerning the connection between the growth of coefficients and that of solutions for complex linear differential equations in the unit disk has been a topic for many studies recently. The authors investigate the interaction between the coefficients and solutions for linear differential equations and for Riccati differential equations in terms of their asymptotic values as described by the MacLane class. (Received September 12, 2008)

1046-30-968 **Tim Ferguson*** (tjferg@umich.edu), Department of Mathematics, 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109. *Continuity of Extremal Elements in Uniformly Convex Spaces and Ryabykh's Theorem.*

We study the problem of finding the extremal element for a linear functional over a uniformly convex Banach space. We discuss our results showing that a unique extremal element exists and depends continuously on the linear functional, and vice-versa. Using these results, we discuss how to simplify and clarify Ryabykh's proof that for any linear functional on a uniformly convex Bergman space with kernel in a certain Hardy space, the extremal functional belongs to the corresponding Hardy space. (Received September 13, 2008)

1046-30-981 **Michael Eisermann*** (Michael.Eisermann@ujf-grenoble.fr), Institut Fourier, Universite Grenoble 1, 100 rue des Maths, BP 74, 38402 St Martin d'Heres, France. *An effective proof of the Fundamental Theorem of Algebra via Sturm chains.*

Sturm's famous theorem provides an elegant algorithm to count and locate the real roots of any given real polynomial. It is less widely known that Cauchy extended this to an algebraic method to count and locate the complex roots of any given complex polynomial. We give an algebraic proof of this beautiful result, starting from the mere axioms of the fields $\mathbb{R}$ and $\mathbb{C}$, without any further appeal to analysis. From this we derive a real algebraic proof of the Fundamental Theorem of Algebra, stating that every complex polynomial of degree n has precisely n complex roots. The proof is constructive and provides an explicit root finding algorithm. The proof is elementary inasmuch as it uses only polynomial arithmetic and the intermediate value theorem for real polynomials in one variable. As a consequence, all arguments hold over an arbitrary real closed field. (Received September 13, 2008)

1046-30-1052 **Catherine Beneteau*** (cbenetea@cas.usf.edu), **Brent Carswell** and **Sherwin Kouchekian**. *Zeros of certain kernel functions in the Fock space.* Preliminary report.

This talk deals with certain kernel functions in the Fock space of entire functions. In particular, if we consider zero based subspaces of the Fock space, it is not difficult to see that the corresponding extremal function has infinitely many additional zeros. In this talk, I will study the structure of these additional zeros under some special hypotheses and discuss some concrete examples. (Received September 14, 2008)

1046-30-1260 **David Dumas*** (ddumas@math.uic.edu), University of Illinois at Chicago, 851 S. Morgan St. M/C 249, Chicago, IL 60607, and **Richard P. Kent** (rpkfour@gmail.com). *Bers slices are Zariski dense.*

We show that every Bers slice of quasi-Fuchsian space is Zariski dense in the $\mathrm{SL}_2(\mathbb{C})$ character variety of $\pi_1(S)$, for any compact oriented surface S. The proof involves complex projective structures on Riemann surfaces and the logarithmic limit sets of affine algebraic varieties. (Received September 15, 2008)

1046-30-1309 **Jonathan Meshes*** (jmeshes@gmail.com), 3733 Clarence Ave., Berwyn, IL 60402. *A Value Distribution Result for Functions of Small Growth in the Unit Disk.* Preliminary report.

Functions meromorphic in the complex unit disk $D = \{z : |z| < 1\}$ can be divided into those of small growth and large growth as measured by the Nevanlinna characteristic function $T(r, f)$. We let $\mathcal{F}$ be those functions f meromorphic in D for which

$$\limsup_{r\to 1^-} \frac{T(r,f)}{\log \frac{1}{1-r}} < \infty.$$

$\mathcal{F}$ is the set of functions of so-called small growth in D, as measured by $T(r, f)$. It is known that $\mathcal{F}$ is closed under addition, multiplication and differentiation. However, there exist analytic functions $f \in \mathcal{F}$ for which $\int f \notin \mathcal{F}$. We let $\mathcal{S}$ denote this class of analytic functions.

We consider the distribution of roots of the equation $f(z) = a$ for different values of a where f is in $\mathcal{S}$ and the function h in D which has $h' = f$. Our feature theorem will tell us that for functions h with $h' = f \in \mathcal{S}$, h cannot omit any finite values. In fact we will give an estimate on the number of roots of the equation $h(z) = a$ for any $a \in \mathbb{C}$. (Received September 15, 2008)

1046-30-1442 **Mark E. Lund*** (lund@math.niu.edu), Department of Mathematical Sciences, Northern Illinois University, DeKalb, IL 60115-2888. *Clunie Type Theorems for Annuli.*

Suppose f is a solution to a complex differential equation $P(z, f)A^*(z, f) = B^*(z, f)$, where P is a polynomial of f with meromorphic coefficients, and A^* and B^* are polynomials of f and its derivatives with meromorphic coefficients. A Clunie type theorem is one in which a bound is given for the proximity function $m(r, A^*)$ and plays in important role in the study of complex differential equations. A Mohon'ko type theorem is one in which a bound is given for $m(r, 1/(f-c))$. We prove versions of Clunie and Mohon'ko type theorems for annuli, extending results of Khrystiyahnyn, Kondratyuk and Laine. To this end, we prove a version of a well-known theorem of Gol'dberg and Ghrinshtein for functions meromorphic in an annulus. We apply these results to calculate bounds for the proximity functions of several classical functions that are meromorphic in annuli. Finally, we present Clunie type theorems for a disk. (Received September 16, 2008)

1046-30-1463 **Philip P. Mummert*** (phmummert@taylor.edu), Taylor University, 236 W. Reade Ave., Upland, IN 46989. *Holomorphic Motions and Hénon Maps.*

The McMullen-Sullivan holomorphic motion for post-critically stable complex polynomials with connected Julia sets respects dynamics and follows level sets of the Böttcher coordinate. This holomorphic motion is formed by a unique extension due to Bers and Royden. Analogously, in $\mathbb{C}^2$, the Buzzard-Verma holomorphic motion for hyperbolic, unstably-connected polynomial diffeomorphisms follows level sets of the Bedford-Smillie solenoid coordinate. One consequence is the injectivity of this solenoid map for those Hénon maps that are perturbations of one-variable hyperbolic polynomials with connected Julia sets. (Received September 15, 2008)

1046-30-1691 **Kourosh Tavakoli*** (tavakoli@fordham.edu). *A Sufficient Condition For Equality Of Hyperbolic metric And Generalized Kobayashi Metric.*

In this talk, I will state a sufficient condition for the equality of hyperbolic metric and generalized Kobayashi metric. Then I will show some geometric and analytic consequences. (Received September 16, 2008)

1046-30-1803 **G. Brock Williams*** (brock.williams@ttu.edu), Dept. of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409. *Riemann Surfaces via Circle Packing.*

Since Thurston's work in the mid-1980's, it has been understood that the geometric behavior of circle packings is deeply connected with the analytic behavior of conformal maps. We will describe combinatorial, analytic, and continued fraction methods of using circle packings to compute coordinates for Riemann surfaces, their deformations, and associated quasiconformal maps. (Received September 16, 2008)

31 ► Potential theory

1046-31-1467 **Lucio M.G. Prado*** (lprado@bmcc.cuny.edu), Department of Mathematics - BMCC, The City University of New York, 199 Chambers Street, New York, NY 10007. *p-Capacity formulas for Z^n and T_d.*

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 very useful to handle the existence or nonexistence of solutions in the class of p-Dirichlet functions to the Poisson equation for p-Laplacian. Our talk will focus on how to get explicit formulas for the computation of the p-capacity of the lattices Z^n and the homogenous trees T_d , which allow their classification in terms p-hyperbolicity and p-parabolicity.
(Received September 16, 2008)

32 ► Several complex variables and analytic spaces

1046-32-191 **Malgorzata S Stawiska*** (stawiska@ku.edu), 1460 Jayhawk Blvd., Lawrence, KS 66045, and **Maritza M. Branker** (mbranker@niagara.edu). *Weighted homogeneous pluripotential theory.*

We introduce a weighted version of the pluripotential theory on complex Kähler manifolds developed recently by Guedj and Zeriahi. We define a weighted pluricomplex Green function, prove its basic properties and study its behavior under holomorphic maps. For projective algebraic manifolds we also provide a homogeneous version of the weighted theory and generalize so-called Siciak's H-principle and some classical approximation results. (Received August 15, 2008)

1046-32-901 **Jerry R Muir, Jr.*** (muirj2@scranton.edu), Department of Mathematics, University of Scranton, Scranton, PA 18510. *Extension of Convex Mappings of Order α of the Unit Disk in $\mathbb{C}$ to Convex Mappings of the Unit Ball in $\mathbb{C}^n$.* Preliminary report.

For a convex mapping f of order $\alpha \in [0,1)$ of the unit disk in $\mathbb{C}$, we consider conditions on the parameter $\beta \in [0,1/2]$ so that the mapping $F(z) = (f(z_1), [f'(z_1)]^\beta \hat{z})$, $\hat{z} = (z_2,\ldots,z_n)$, is a convex mapping of the Euclidean unit ball in $\mathbb{C}^n$. (Received September 12, 2008)

1046-32-1208 **Georgios D. Daskalopoulos** (daskal@math.brown.edu), Department of Mathematics, Brown University, 151 Thayer Street, Providence, RI 02912, and **Richard A. Wentworth*** (raw@umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *Cohomology of SL(2,C) character varieties of surface groups and the action of the Torelli group.*

We determine the action of the Torelli group on the equivariant cohomology of the space of flat SL(2,C) connections on a closed Riemann surface. We show that the trivial part of the action contains the equivariant cohomology of the even component of the space of flat PSL(2,C) connections. The non-trivial part consists of the even alternating products of degree two Prym representations, so that the kernel of the action is precisely the Prym-Torelli group. We compute the Betti numbers of the ordinary cohomology of the moduli space of flat SL(2,C) connections. Using results of Cappell-Lee-Miller we show that the Prym-Torelli group, which acts trivially on equivariant cohomology, acts non-trivially on ordinary cohomology. (Received September 15, 2008)

1046-32-1713 **Jennifer Halfpap*** (halfpap@mso.umt.edu), UM Dept. of Mathematical Sciences, 32 Campus Drive, Missoula, MT 59812. *Behavior of $\int \exp(rz - b(r))\, dr$ for Smooth b: Connections with the Szegö Projection Operator.*

Consider the hypersurface

$$M = \{\, (z_1, z_2) : \mathrm{Im}(z_2) = b(\mathrm{Re}(z_1)) \,\}$$

where b is smooth and satisfies $\lim_{|r|\to\infty} b(r)/|r| = \infty$. For such M, the Szegö projection operator has an associated kernel

$$S[(z_1,z_2),(w_1,w_2)] = \iint_{\tau>0} \frac{e^{\eta[z_1+\bar{w_1}]+i\tau[z_2-\bar{w_2}]}}{N(\eta,\tau)}\, d\eta\, d\tau$$

where $N(\eta,\tau) = \int \exp(2[\eta r - \tau b(r)])\, dr$. Thus the nature and location of the singularities of S are intimately tied to the behavior of N. In this talk we explore size estimates for N as well as the location of the complex zeros of the entire function obtained by replacing η with a complex variable. We relate this to results obtained with Nagel and Wainger on the Szegö projection operator when M has a point of infinite type. (Received September 16, 2008)

1046-32-1809 **Daniel J. Miller*** (dmille10@emporia.edu), Emporia State University, Department of, Mathematics, Computer Science and Economics, 1200 Commercial Street, Campus Box 4027, Emporia, KS 66801, and **Raf Cluckers**, Katholieke Universiteit Leuven, Departement Wiskunde, Celestijnenlaan 200B, B-3001, Leuven, Belgium. *Sums of products of real globally subanalytic functions and their logarithms are stable under integration.*

We prove two basic theorems on (Lebesgue) integration of sums of products of globally subanalytic functions and their logarithms, called constructible functions. The first theorem states that constructible functions are closed under integration, and the second treats integrability issues in families. These theorems generalize and provide a natural framework for the previous work by Lion - Rolin [1] and by Comte - Lion - Rolin [2] on parameterized integrals and on parameterized volumes of globally subanalytic sets.

[1] J.-M. Lion and J.-P. Rolin, *Intégration des fonctions sous-analytiques et volumes des sous-ensembles sous-anaytiques*, Ann. Inst. Fourier (Grenoble) **48** (1998), 755-767.

[2] Comte, G. and Lion, J.-M. and Rolin, J.-P., *Nature log-analytique du volume des sous-analytiques*, Illinois J. Math. **44** (2000), no. 4, 884-888. (Received September 16, 2008)

33 ► Special functions

1046-33-140 **Jemal E Gishe***, Department of Mathematics, Western Kentucky University, 1906 College Heights Blvd#11078, Bowling Green, KY 42101, and **Mourad Ismail**. *A Finite Family of q-Orthogonal Polynomials.*

For $q > 1$ the continuous q-Jacobi polynomials form a finite family of polynomials orthogonal on the imaginary axis. We make a proper normalization to form system of Polynomials that are orthogonal along real axis. As a byproduct we will compute its closed form, three term recurrence relation, eigenvalue equation, Rodrigues formula and generating function. We also evaluate the discriminants of the polynomials of arbitrary degrees. (Received August 05, 2008)

1046-33-183 **Roger W. Barnard** (roger.w.barnard@ttu.edu), Department of Mathematics, Texas Tech University, Lubbock, TX 79409, **Michael B. Gordy** (Michael.Gordy@frb.gov), Division of Research & Statistics, Board of Governors, Federal Reserve System, Washington, DC 20551, and **Kendall C. Richards*** (richards@southwestern.edu), Department of Mathematics, Southwestern University, Georgetown, TX 78628. *A Turán Type Inequality for the Kummer Function Arising in Finance. Part II: The Verification.*

We use contiguous relationships and properties of the digamma function to verify the following generalized Turán-type inequality involving Φ, the Kummer confluent hypergeometric function: Suppose $a, b > 0$. Then for any $\nu \in \mathbb{N}$ with $a, b \geq \nu - 1$

$$\Phi(a, a+b, x)^2 > \Phi(a+\nu, a+b, x)\,\Phi(a-\nu, a+b, x)$$

for all nonzero $x \in \mathbb{R}$. This inequality complements the recently obtained Turán-type inequalities of Árpad Baricz for combinations of Kummer functions involving $\Phi(a \pm \nu, c \pm \nu, x)$ and $\Phi(a, c \pm \nu, x)$. (Received August 13, 2008)

1046-33-404 **Timothy B Flowers*** (tflower@clemson.edu), Department of Mathematical Sciences, Box 340975, Clemson, SC 29634-0975, and **Neil J Calkin**. *Asymptotics of Bernoulli, Euler, and Strodt Polynomials.*

It is well known that both Bernoulli polynomials and Euler polynomials on a fixed interval are asymptotically sinusoidal. A recent paper by Borwein, Calkin, and Manna uses an idea of Strodt to generalize Bernoulli and Euler polynomials and view them as members of a family of polynomials. We used these ideas to study the asymptotics of non-uniform Strodt polynomials. We will describe the experimental process which led to several conjectures. In addition, we will show how experiments suggested the methods used to prove some of these results. (Received August 31, 2008)

1046-33-658 **Mourad E. H. Ismail*** (ismail@math.ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32828, and **Josef Obermaier**, Helmholtz Zentrum München, German Research Center for Environmental Heal, Institute of Biomathematics and Biometry, Munich, Germany. *Characterizations of Continuous and Discrete q-Ultraspherical Polynomials.*

We characterize the continuous q-ultraspherical polynomials in terms of the special form of the coefficients in the expansion $\mathcal{D}_q P_n(x)$ in the basis $\{P_n(x)\}$, $\mathcal{D}_q$ being the Askey-Wilson divided difference operator. The polynomials are assumed to be symmetric and the connection coefficients are multiples of the reciprocal of the square of the L^2 norm of the polynomials. A similar characterization is given for the discrete q-ultraspherical polynomials. A new proof of the evaluation of the connection coefficients for big q-Jacobi polynomials is given. (Received September 09, 2008)

1046-33-1183 **Olivier Oloa*** (olivier.oloa@wanadoo.fr), 38 chemin Orme Aigu, 78660 Ablis, France. *New formulas for Euler log-trigonometric integrals.* Preliminary report.

We establish a formula for
$$\int_0^{\pi/2} \theta^n \ln^p (2\cos\theta)\, \mathrm{d}\theta,$$
where n is a positive even integer, p being any positive integer. We use *Mathematica* to guess a formula in the case of n being odd. (Received September 15, 2008)

1046-33-1328 **A. Sri Ranga*** (ranga@ibilce.unesp.br), DCCE / IBILCE / UNESP, S.J. do Rio Preto, SP 15054-000, Brazil, **Regina da Silva Lamblém**, IBILCE / UNESP, S.J. do Rio Preto, SP 15054-000, Brazil, and **Heron Martins Felix**, IBILCE / UNESP, S.J. do Rio Preto, SP 15054-000, Brazil. *Some relations between orthogonal L-polynomials and orthogonal polynomials.*

Szegő (see for example his book) introduced the mapping $2x = z + 1/z$ between real Szegő polynomials (i.e. real orthogonal polynomials on the unit circle) and orthogonal polynomials on the interval $[-1, 1]$. Using this mapping Geronimus in [1962] derived the relations between the coefficients of the associated recurrence relations. Delsarte and Genin [1986], through the mapping $2x = \sqrt{z} + 1/\sqrt{z}$, obtained the connection between real Szegő polynomials and symmetric orthogonal polynomials on $[-1, 1]$, which was further explored, for example, in Zhedanov [1994]. In Sri Ranga [1995] the mapping $2x = \sqrt{t} - 1/\sqrt{t}$ was used to obtain a relation between a type of orthogonal L-polynomials on $(0, \infty)$ and symmetric orthogonal polynomials on $(-\infty, \infty)$. Finally in Andrade, Bracciali and Sri Ranga [2007] the mapping $2x = z + 1/z$ was used to obtain a relation between another type of orthogonal L-polynomials on $(0, \infty)$ and orthogonal polynomials on $(1, \infty)$. The objective here is to look at these relations from a different point of view. This also reveals some Relations between T-fractions and J-fractions. (Received September 15, 2008)

1046-33-1638 **Flavia Stan*** (fstan@risc.uni-linz.ac.at), RISC, Johannes Kepler University, Altenbergerstr 69, 4040 Linz, Austria. *Algorithmic Proofs for Special Function Identities.*

We use computer algebra algorithms, mainly based on WZ-summation methods and on refinements by K. Wegschaider, to prove identities involving hypergeometric multi-series. These techniques have found new applications, for instance in various theoretical physics problems. (Received September 16, 2008)

34 ► Ordinary differential equations

1046-34-40 **Britney Hopkins*** (Britney_Hopkins@baylor.edu), Department of Mathematics, Baylor University, Waco, TX 76798-7328. *Multiplicity of positive solutions for an even-order nonhomogeneous boundary value problem.*

In this talk, we focus on the existence of multiple positive solutions for the $2n$th order ordinary differential equation, $u^{(2n)} = \lambda h\left(t, u, u'', \dots, u^{(2n-2)}\right)$, $t \in (0, 1)$, satisfying the boundary conditions, $u^{(2k)}(0) = 0$ and $u^{(2k)}(1) = (-1)^k a_k$ for $k = 0, \dots, n-1$, where $h : [0, 1] \times \prod_{i=0}^{n-1} (-1)^n [0, \infty) \to (-1)^n [0, \infty)$ is continuous, $\lambda, a_k \geq 0$ for $k = 0, \dots, n-1$, and $\sum_{k=0}^{n-1} a_k > 0$. We transform the boundary value problem into a system of second order boundary value problems and then apply the Guo-Krasnosel'skii Fixed Point Theorem multiple times, establishing the existence of several positive solutions. (Received June 26, 2008)

1046-34-59 **Omayra Y Ortega*** (omayra.ortega@asu.edu), Arizona State University, Division of Mathematical and Natural Sciences, 4701 W Thunderbird Rd, Glendale, AZ 85306.
Evaluation of Rotavirus Models with Coinfection and Vaccination.

Rotavirus diarrhea causes a disproportionate amount of childhood mortality. Approximately 611,000 children die each year due to complications of rotavirus infections. We evaluate rotavirus vaccination using four different methods. We look at the epidemiological history of the disease and vaccination against the disease, then we evaluate the effectiveness of vaccination first using a cost-benefit analysis, then using an ordinary differential equations based model, and last through computer simulations.

We do a traditional cost-benefit analysis to evaluate the costs and benefits of implementing a rotavirus vaccination program in Egypt with the RotaRix vaccine. Our results show that given the current standards of care in Egypt, it would be more cost-beneficial for Egypt not to use the rotavirus vaccine.

We formulate a model of the spread of rotavirus diarrhea based on a continuous time ordinary differential equations model of two viral strains of influenza. We expand this model to include the case of co-infection. We further expand the original model to explore the effects of vaccination.

Our simulations of the models show that the spread of the disease is highly sensitive to the levels of cross-immunity between the strains, and the level of vaccination in the population. (Received July 16, 2008)

1046-34-104 **Benjamin Baxter*** (baxterb2@nku.edu), 1322 Boat Run Lane, New Richmond, OH 45157, and **Lisa J Holden** (HOLDENL@nku.edu), Department of Mathematics, Northern Kentucky University, Nunn Drive, Highland Heights, KY 41099. *Examining the Evolution of Molecular Gas in the Interstellar Medium: The Case of the Singular Ordinary Differential Equations.* Preliminary report.

We consider the collapse and/or wind solutions of a self-gravitating cylindrically symmetric gas. The situation is described by a set of partial differential fluid equations. These equations allow for a self-similar analysis, enabling us to reduce the system to a set of ordinary differential equations. Previous studies have described an "inside-out" collapse solution for certain regions of parameter space. We focus on constructing solutions that cross singular points smoothly. After identifying the surface on which the differential equations become singular, we impose conditions such that the solutions will not diverge as they cross the resulting critical curve. We then obtain a Taylor series expansion of our analytic solution valid in a neighborhood about the critical point. Integrating both outward and inward from the critical point, we obtain a global solution. Finally, we consider our results in the context of star formation. (Received July 23, 2008)

1046-34-291 **Gro Hovhannisyan*** (ghovhann@kent.edu), 6000 Frank Avenue, North Canton, OH 44720. *Adiabatic invariants for 2D Linear Dynamic Systems on Time Scales.* Preliminary report.

We introduce an adiabatic invariant for 2D dynamic systems on a time scale, using the properties of the ratio of Wronskians. Note that this adiabatic invariant is a generalization of the adiabatic invariant of Lorentz's pendulum. Using the construction of fundamental solution of 2D linear dynamic system on a time scale, and WKB series by a small positive parameter, we prove that the change of the adiabatic invariant is vanishing as the small parameter approaches zero. We show that this result is true for the difference equations only for appropriate choice of graininess depending on the small parameter. We show also that the change of adiabatic invariant may be estimated above by any positive power of the small parameter. (Received August 25, 2008)

1046-34-409 **Rachael L Miller*** (rmiller@math.utk.edu), **Suzanne Lenhart** and **Elsa Schaefer**.
Optimal intervention strategies for a cholera outbreak.

Caused by the bacterium Vibrio cholerae, cholera has caused deadly epidemics for almost two hundred years. However, no strategy for its effective control exists today. Past research has shown that Vibrio cholerae passes from a hyper infectious state (HI) to a less infectious state (non-HI) within hours. We present a system of ordinary differential equations modeling the interactions between S-I-R individuals and HI and non-HI vibrios. Incorporated into the model are the effects of sanitation, hydration therapy, vaccination and antibiotics as possible control methods. Using optimal control theory, we present optimal intervention schedules one might use in controlling the spread of cholera. (Received September 02, 2008)

1046-34-472 **Jagdish Chandra*** (jchandra@gwu.edu), 1776 G Street,NW, # 137, Washington, DC 20052, and **G S Ladde**, 4202 east fowler avenue, PHY114, tampa, FL 33620.
Cooperative/competitive dynamics in social networks. Preliminary report.

Social networks are metaphor and mathematical constructs for relationship among individuals (groups of individuals). In social networks, nodes represent individual or groups (agents), who may have both observable characteristics (such as location, stockpiles, association/employer, etc.), and unobservable characteristics (such as suspicion, political/religious affiliations, opinions, preferences, etc.), while edges represent associations between pairs of agents. In this study, we are primarily interested in dynamic networks, where both nodes and associations evolve in time. In this preliminary report, we represent the dynamics of relationships between "individuals" by a coupled systems of nonlinear deterministic or stochastic differential equations that combine both the interaction dynamics and behavioral dynamics, where the pair-wise relationships are driven by both observable and unobservable characteristics. We present some qualitative properties such as resilience, coherence, and stability, employing energy (Liapunov)-like function methods. (Received September 04, 2008)

1046-34-477 **Steve Baer**, **Bingtuan Li** and **Hal L. Smith*** (halsmith@asu.edu), Dept. of Math. & Stat., Arizona State University, Tempe, AZ 85287. *Multiple limit cycles in the standard model of three species competition for three essential resources.*

We consider the dynamics of the standard model of three species competing for three essential resources in a chemostat using Liebig's law of the minimum functional response. A subset of these systems which possess cyclic symmetry such that its three single-population equilibria are part of a heteroclinic cycle bounding the two-dimensional carrying simplex is examined. We show that a subcritical Hopf bifurcation from the coexistence equilibrium together with a repelling heteroclinic cycle leads to the existence of at least two limit cycles enclosing the coexistence equilibrium on the carrying simplex. Numerical simulations suggest that there are exactly two limit cycles and that almost every positive solution approaches either the stable limit cycle or the stable coexistence equilibrium, depending on initial conditions. In an alternative scenario, we show that the subcritical Hopf together with an attracting heteroclinic cycle leads to an unstable periodic orbit separatrix. (Received September 04, 2008)

1046-34-490 **Aghalaya S Vatsala***, Professor Aghalaya S. Vatsala, Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010. *Fractional Differential and Integral Equations of Riemann-Liouville versus Caputo type.* Preliminary report.

In mathematical modeling, nonlinear fractional differential and integral equations occur naturally in various areas of science and engineering. It is also established these models yield better results than their counter part with integer derivatives. In this work, we develop the theory of fractional differential and integral inequalities for Rieman-Liouville as well as with Caputo derivative. This will be used to obtain the qualitative behavior of fractional differential, and integral equations of both type. We will also compare their relative advantages. (Received September 04, 2008)

1046-34-547 **S Sivasundaram*** (seenithi@gmail.com), 104, Snow Goose Ct, Daytona Beach, FL 32119. *Basic results and stability criteria for set valued differential equations on time scales.*

We develop some basic results for set valued differential equations on time scales. Sufficient conditions for the stability of the trivial solution of set valued differential equations on time scales are also discussed. (Received September 07, 2008)

1046-34-551 **Suzanne S Sindi*** (ssindi@dam.brown.edu), 182 George Street, Providence, RI 02912. *Modeling the Evolution of Repetitive Sequence in DNA.*

There are many nearly identical sequences within the genomes of human, fly, worm and every non-microbial genome that has been determined. Such sequences were originally hypothesized to be "junk DNA", but biologists continue to find many functions these sequences perform. I have been modeling the evolution of these sequences with dynamical systems.

Several features of repetitive DNA follow power law distributions, a natural question is how such distributions have emerged over time from individual duplication events. I will describe evolutionary models demonstrating how power law and generalized Pareto Law distributions can emerge naturally from random duplication and deletion in a genome. (Received September 07, 2008)

1046-34-634 **Mario Umberto Martelli*** (mario.martelli@cgu.edu), 710 North College Blvd, Claremont, CA 91711. *On the Longitudinal Librations of Hyperion.*

The longitudinal librations of the satellite Hyperion will be studied under the assumption that the spin axis remains perpendicular to the orbit plane. It will be shown that with probability 1 they are unpredictable. (Received September 09, 2008)

1046-34-657 **Mohsen Razzaghi*** (razzaghi@math.msstate.edu), Department of Mathematics and Statistics, Mississippi State University, Mississippi State, MS 39762. *A numerical solution for a nonlinear integro-differential equation in a population model.*

A numerical method for solving Volterra's population model for population growth of a species in a closed system is proposed. Volterra's model is a nonlinear integro-differential equation where the integral term represents the effects of toxin. The approach is based upon hybrid function approximations. The properties of hybrid functions which consists of block-pulse and Legendre polynomials are presented. The associated operational matrices of integration and product are then utilized to reduce the solution of the Volterra's model 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 09, 2008)

1046-34-698 **Don Hinton** and **Maeve L McCarthy*** (maeve.mccarthy@murraystate.edu), Mathematics & Statistics, 6C Faculty Hall, Murray, KY 42071. *A Mass, a Spring, and a String.*

We consider the problem of the oscillation of a string fixed at one end with a mass connected to a spring at the other end. The problem is investigated of minimizing the first eigenvalue of the system when subjected to a fixed total mass constraint. For a small spring constant, the minimum eigenvalue is obtained by concentrating all the mass the the end with the spring. As the spring constant is increased, a critical value is reached so that beyond this point the minimum eigenvalue is obtained by concentrating all the mass at an interior point. (Received September 10, 2008)

1046-34-713 **Marc Chamberland*** (chamberl@math.grinnell.edu), Department of Mathematics and Statistics, 1116 8th Avenue, Grinnell College, Grinnell, IA 50112. *Global Stability with Dulac Functions.*

The most well-known general approach to prove global stability of an equilibrium point for a system of differential equations is to use Lyapunov functions. However, finding an appropriate Lyapunov function usually requires lots of experience, hard work, and perhaps some luck. Less demanding to find are Dulac functions which are used in planar systems to eliminate periodic orbits. In this talk, we see that Dulac functions are sometimes enough to give the desired stability. Tied in this work are so-called Jacobian Conjectures. (Received September 10, 2008)

1046-34-790 **Aaron Hoffman** and **Benjamin Kennedy*** (bkennedy@gettysburg.edu), Department of Mathematics, Gettysburg College, 300 N. Washington St., Gettysburg, PA 17325. *Existence and uniqueness of traveling waves in a class of unidirectional lattice differential equations.*

We discuss the existence and uniqueness, for wave speeds sufficiently large, of monotone traveling wave solutions connecting 0 and 1 for a class of N-dimensional lattice differential equations with unidirectional coupling. The class of systems that we study includes as a special case the one-dimensional lattice equation

$$u_n' = -u_n + u_{n-1}^2.$$

(Received September 11, 2008)

1046-34-840 **Zhivko S. Athanassov*** (zhivko@math.bas.bg), G. Bonchev Str. 8, 1113 Sofia, Bulgaria. *Stability of Perturbed Almost Periodic Ordinary Differential Equations.* Preliminary report.

We will discuss the preservation of stability of systems of almost periodic differential equations under perturbations. Consider the following systems: (N) $x' = f(t,x)$ and (P) $x' = f(t,x) + g(t,x)$, where $f(t,x)$ is almost periodic in t, $f(t,0) = 0$, and $x = 0$ is uniformly asymptotically stable for (N). We use techniques originated essentially by H. Okamura to establish conditions on f and g for the origin to be integrally and totally asymptotically stable. Results are also obtained for special cases of (N) such as linear and periodic equations. (Received September 12, 2008)

1046-34-845 **Marat Akhmet*** (marat@metu.edu.tr), Department of Mathematics, Middle East Technical University, 06531 Ankara, Turkey. *Poisson stability and chaos of relay systems.*

Poisson stable trajectories give a strong evidence of the chaotic attractor [L. Shilnikov, Bifurcations and strange attractors. Proceedings of the International Congress of Mathematicians, Vol. III (Beijing, 2002), 349–372, Higher Ed. Press, Beijing, 2002.]. Lorenz system is the famous example. Fully developed existence of the trajectories for a class of relay systems will be discussed. An appropriate simulation result is provided. (Received September 12, 2008)

1046-34-850 **Cemil Buyukadali*** (bcemil@metu.edu.tr), Department of Mathematics, Middle East Technical University, 06531 Ankara, Turkey, and **Marat Akhmet** (marat@metu.edu.tr), Department of Mathematics, Middle East Technical University, 06531 Ankara, Turkey. *On periodic solutions of quasilinear differential equations with piecewise constant argument of generalized type in critical case.*

The periodic quasilinear system of differential equations with small parameter and piecewise constant argument of generalized type [M.U. Akhmet, On the reduction principle for differential equations with piecewise argument of generalized type, J. Math. Anal. Appl. 336 (2007) 646–663] is addressed. We consider the critical case, when associated linear homogeneous system admits nontrivial periodic solutions. Criteria of existence of periodic solutions of such equations are obtained. One of the main auxiliary results of our paper is an analogue of Gronwall Bellman Lemma for functions with piecewise constant and retarded advanced type arguments. Dependence of solutions on the parameter is investigated. Appropriate examples are given to show our results. (Received September 12, 2008)

1046-34-863 **Arthur S Sherman*** (asherman@nih.gov), 12A South Drive, Room 4007, Bethesda, MD 20892-5621. *Oscillations of Calcium, Metabolism, and Insulin Secretion in Pancreatic Beta-cells.*

Glucose is essential for life but is damaging at high levels and blood glucose levels must be maintained within narrow limits. The hormone insulin promotes glucose storage and consumption to blunt the rise after a meal. Defects in this system result in diabetes.

Mathematical interest has focused on modeling insulin secretion by the beta-cells of the pancreas. The first successful model was developed 25 years ago by Chay and Keizer, to explain the bursting electrical oscillations that drive the rises in calcium that are the main trigger for insulin release. The model followed the Hodgkin-Huxley paradigm for electrical activity in neurons and other excitable tissues, such as the heart, but this ubiquitous electrical sub-system is embedded in hormonal and metabolic regulatory networks. The metabolic component further shows evidence of ability to oscillate semi-independently of the electrical component, resulting in a rich repertoire of interactions and outputs. The Dual Oscillator Model combines all of these elements and can account for most of the observed behaviors of beta-cells. The development of this model through multiple iterations between theory and experiment and the challenges for dynamical systems analysis will be discussed. (Received September 12, 2008)

1046-34-910 **Valerie N. Nelson*** (vnelson75@gmail.com), Department of Mathematics, Carnegie 251, 1700 E. Cold Spring Lane, Baltimore, MD 21251, and **Gaston M. N'Guerekata** and **Khalil Ezzinbi**. *$C^{(n)}$-Almost Automorphic Solutions of Some Nonautonomous Differential Equations.*

We are concerned with the existence of $C^{(n)}$-almost automorphic solutions of the equation $x'(t) = A(t)x(t)+f(t)$ where $A(t)$ is a τ-periodic operator and $f(t)$ is $C^{(n)}$-almost automorphic. We prove a Massera-type result for the nonautonomous case in C^k. We also show that every bounded mild solution is $C^{(n)}$-almost automorphic when $A(t) = A$ generates a quasi-compact semigroup of operators. (Received September 12, 2008)

1046-34-933 **James A Yorke*** (yorke@umd.edu), Math Dept, Univ of Maryland, College Park, MD 20742. *Modeling HIV outbreaks: The Male to Female Prevalence Ratio in the Core Population.*

This is joint work with Brandy Rapatski. What affects the ratio of infected men to infected women in the core population in a heterosexual HIV epidemic? Hethcote & Yorke introduced the term "core" initially to loosely describe the collection of individuals having the most unprotected sex partners. We study the early epidemic during the exponential growth phase and focus on the core group since most infected people were infected by people in the core. We argue that in the early outbreak phase of an epidemic, there is an identity which we call the "outbreak equation". It relates three ratios that describe the core men versus the core women, namely, the ratio E of numbers of all core men to all core women, the ratio C of numbers of infected core men to core women, and the ratio M of the infectiousness of a typical core man to that of a typical core woman. Then the relationship between the ratios is $E = MC^2$ in the early outbreak phase. We investigate two very different scenarios, one in which there are two times as many core men as core women ($E = 2$) and the other in which core men equal core women ($E = 1$). In the first case, the HIV epidemic grows at a much faster rate. (Received September 12, 2008)

1046-34-949 **C. David Pruett*** (pruettcd@jmu.edu), Department of Mathematics and Statistics, MSC 1911 James Madison University, Harrisonburg, VA 22807, and **William H. Ingham** (inghamwh@jmu.edu), Department of Physics and Astronomy, MSC 4502 James Madison University, Harrisonburg, VA 22807. *The Ultimate N-Body Algorithm: Parameter-Free, Adaptive, and Parallel.*

Picard iteration, normally considered a theoretical rather than a computational tool, is customarily used to establish existence and uniqueness of solutions to systems of first-order ordinary differential equations (ODEs) of initial-value type. However, about a decade ago, Parker and Sochacki [*Neural, Parallel, and Sci. Comput.* 4, 1996] adopted Picard iteration to develop a practical numerical scheme of arbitrarily high order and suitable for a wide class of initial-value ODEs termed "projectively polynomial;" that is, whose generators can be cast as polynomials in the unknowns. The N-body problem, of both historical and practical interest, falls into this class. The scheme was subsequently adapted to the N-body problem and rendered adaptive in time and order by Pruett, Rudmin, and Lacy [*J. Comput. Phys.* 187, 2003]. In the current paper, the N-body algorithm is further enhanced to exploit data parallelism. The resulting algorithm, developed from first principles in the talk, has several attractive attributes: it is parameter-free, it minimizes computational effort by being simultaneously adaptive in time and order, and it enjoys linear speedup on distributed parallel processors. (Received September 12, 2008)

1046-34-984 **Robert J Decker*** (rdecker@hartford.edu), University of Hartford, Mathematics Dept, 200 Bloomfield Ave, West Hartford, CT 06117, and **V W Noonburg** (noonburg@hartford.edu), University of Hartford, Mathematics Dept, 200 Bloomfield Ave, West Hartford, CT 06117. *A periodically forced, cubic-like, single neuron equation with multiple attractors.*

The authors investigate a class of periodically forced, first-order differential equations of the form $y' = -y + S(y - f(t))$, where $f(t)$ is periodic and S is sigmoidal. Such an equation has a cubic-like shape, and variations of it are used as a component in certain models in computational neuroscience (such as the Wilson-Cowan equations). It is known that for equations which are cubic in y and periodic in t, and for which the cubic term has constant sign, that there can be at most three isolated periodic solutions. The authors show that for the class of equations under investigation, more than three isolated periodic solutions can be obtained.

A pitchfork bifurcation is demonstrated analytically for the simplest equation of this class of equations; for certain parameter ranges this results in a bifurcation from three to five periodic solutions. It is then shown that a function $f(t)$ can be explicitly constructed with arbitrarily many isolated periodic solutions, by approximating a piecewise function with a truncated Fourier series. Finally, it is shown how to develop models with a small number of Fourier terms and a large number of periodic solutions and possible bifurcation routes to such large numbers of periodic solutions are calculated numerically. (Received September 13, 2008)

1046-34-1074 **Jianzhong Su** (su@uta.edu), 411 S. Nedderman Dr., 478 PKH, Arlington, TX 76019, and **Humberto Perez*** (humbe_pg@uta.edu), 411 S. Nedderman Dr., 478 PKH, Arlington, TX 76019. *Regular Bursting Emerging from Synaptically Coupled Elliptic Bursters.* Preliminary report.

In this note, we study the change of collective behavior of two synaptically coupled elliptic bursters as the level of noise increases. The two cells are desinchronized when coupled but as the coupled strength and the noise level increase past a certain value, the behavior of two cells becomes synchronized with regular bursting motions. (Received September 14, 2008)

1046-34-1152 **Ianna H. West*** (ianna.west@nicholls.edu). *Existence of Solutions for Systems of Differential Equations with Impulses with Application to Ecological Models.*

Systems of differential equations with impulses can occur in the mathematical modeling of science and engineering. In this paper we will show the existence of solutions for such systems. We will develop the generalized monotone iterative method and use it to solve a system involving an ecological model. (Received September 14, 2008)

1046-34-1161 **M Affouf*** (maffouf@kean.edu), Math Dept, Kean University, Union, NJ 07083. *On singular solutions of Clairaut-type differential equations.* Preliminary report.

We present a characterization of the behavior of solutions of higher order ordinary differential equations of Clairaut-type and we show a gallery of numerical solutions of various Clairaut-type equations: ordinary and partial differential equations, explicit and implicit forms. We apply the duality principle of Legendre transformations to compute singular solutions of Clairaut-type differential equations. (Received September 14, 2008)

1046-34-1253 **Paul W Eloe*** (Paul.Eloe@notes.udayton.edu), Department of Mathematics, University of Dayton, Dayton, OH 45469-2316, and **Johnny Henderson**. *Uniqueness Implies Existence and Uniqueness Conditions for a Class of $(k+j)-$Point Boundary Value Problems for nth Order Differential Equations.*

For the nth order nonlinear differential equation, $y^{(n)} = f(x, y, y', \ldots, y^{(n-1)})$, we consider uniqueness implies existence results for solutions satisfying certain $(k+j)-$point boundary conditions, $1 \le j \le n-1$, and $1 \le k \le n-j$. We define $(k;j)-$point unique solvability in analogy to $k-$point disconjugacy and we show that $(n-j_0;j_0)-$point unique solvability implies $(k;j)-$point unique solvability for $1 \le j \le j_0$, and $1 \le k \le n-j$. This result is in analogy to $n-$point disconjugacy implies $k-$point disconjugacy, $2 \le k \le n-1$. (Received September 15, 2008)

1046-34-1258 **Dmitry Altshuller*** (altshuller@ieee.org), Crane Aerospace & Electronics, 3000 Winona Ave, Burbank, CA 91510. *On the Aizerman Problem for Second-Order Systems with Multiple Delays.*

The paper considers the problem described by Rasvan in the book "Unsolved Problems in Mathematical Systems and Control Theory" by Blondel and Megretski. Specifically, we consider the second-order differential equation with multiple delays:

$$\ddot{x} + a_1\dot{x} + \varphi(x) + \sum_{j=1}^{m} b_j x(t-\tau_j) = 0 \tag{1}$$

where the function $\varphi(x)$ satisfies the sector inequality $0 < \varphi(x) < \mu x$.

It will proved that the Aizerman conjecture is true for this type of systems, i.e the stability of this system can be deternied by considering instead the linear system:

$$\ddot{x} + a_1\dot{x} + ax + \sum_{j=1}^{m} b_j x(t-\tau_j) = 0 \tag{2}$$

The proof is based on the Popov criterion for absolute stability.

This is a continuation of the paper delivered by the author at the 2008 SIAM Annual Meeting in San Diego. (Received September 15, 2008)

1046-34-1355 **Andrea Bruder*** (Andrea_Bruder@baylor.edu), Baylor University, Department of Mathematics, One Bear Place #97328, Waco, TX 76798. *An application of the left-definite spectral theory to the Jacobi differential equation for non-classical parameters.*

In 1929, S. Bochner classified all second order equations of hypergeometric type that have orthogonal polynomial eigenfunctions. Up to a complex change of variable, the only such equations are the Hermite, Laguerre, Jacobi, and the Bessel polynomial equations. Since then, it has been well known that, for $-\alpha, -\beta, -\alpha-\beta-1 \notin \mathbb{N}$, the Jacobi polynomials $\left\{P_n^{(\alpha,\beta)}(x)\right\}_{n=0}^{\infty}$ are orthogonal on $\mathbb{R}$ with respect to a bilinear form of the type

$$(f,g)_\mu = \int_{\mathbb{R}} f\overline{g}d\mu,$$

for some measure μ. However, for negative integer parameters α and β, an application of Favard's theorem shows that the Jacobi polynomials cannot be orthogonal on the real line with respect to a bilinear form of this type for any measure. But it is known that they are orthogonal with respect to a Sobolev inner product.

After discussing this Sobolev orthogonality, I will give an introduction to the left-definite spectral theory and show how it can be applied to construct a self-adjoint operator that is generated from the Jacobi differential expression (for non-classical parameters) having the entire sequence of Jacobi polynomials as a complete set of eigenfunctions. (Received September 15, 2008)

1046-34-1425 **Lianwen Wang** (lwang@ucmo.edu), Dept. of Mathematics and Computer Science, University of Central Missouri, Warrensburg, MO 64093, and **Rhonda McKee*** (mckee@ucmo.edu), Dept. of Mathematics and Computer Science, University of Central Missouri, Warrensburg, MO 64093. *Existence of Bounded Monotonic Solutions of Second Order Differential Equations.* Preliminary report.

In this talk the existence of bounded monotonic solutions of a class of second order nonlinear differential equations

$$[p(t)h(x(t))f(x'(t))]' = q(t)g(x(t)),\ t \ge a,$$

(with no monotonic assumption on $g(x)$) is discussed. It has been proved that all solutions of the above differential equation are eventually monotonic, so the set of all solutions except the trivial solution can be classified into two classes

$$A = \{x: \text{ there exists a } \ b \geq a \text{ such that } x(t)x'(t) > 0, \ t \in [b, \alpha)\},$$
$$B = \{x: \ x(t)x'(t) < 0, \ t \in [a, \infty)\}.$$

The existence of both class A and class B solutions are proved. The results obtained have extended and improved some analogous existing ones. (Received September 15, 2008)

1046-34-1587 **Diana M Thomas*** (thomasdia@mail.montclair.edu), 1 Normal Avenue, Montclair, NJ 07043. *The Minimal Period Problem of Mario Martelli.*

In 1969, Jim Yorke proved that if $x(t)$ is a periodic solution of period T to a differential equation defined on a finite dimensional Hilbert Space with Lipschitz constant L, then $TL \geq 2\pi$. This result was extended to infinite dimensional Hilbert Spaces. In the Banach Space case, Yorke and Lasota proved that $TL \geq 4$. During the mid-eighties, Martelli with Busenberg and Fisher verified that $TL \geq 6$ on a Banach Space and that in fact this bound is sharp using an example defined on L_1 of the unit square. In this talk I will go over in detail the history of Martelli's work on this curious and interesting problem along with my own work related to the minimal periods problem posed by Martelli in the Monthly. (Received September 16, 2008)

1046-34-1628 **Jeffrey A Ehme*** (jehme@spelman.edu), Dept of Mathematics, Box 214, 350 Spelman Lane SW, Spelman College, Atlanta, GA 30314, and **Aprillya Lanz** (lanzar@vmi.edu), Dept. of Mathematics and Computer Science, virginia Military Institute, Lexington, VA 24450. *Uniqueness Implies Existence for Nonlinear Focal-Like Boundary Value Problems.*

Given an appropriate growth condition for f and an uniqueness assumption on $y^{(n)} = 0$ with respect to certain focal boundary value problems, it is shown that uniqueness of solutions to the nonlinear differential equation

$$y^{(n)} = f(t, y, y', \ldots, y^{(n-1)})$$

subject to boundary conditions of the form

$$g_{ij}(y(t_j), \ldots, y^{(n-1)}(t_j)) = y_{ij},$$

implies existence of solutions. (Received September 16, 2008)

1046-34-1639 **Simeone Marino*** (simeonem@umich.edu), 1150 West Medical Center Drive, 6730 Medical Science Buikding 2, Ann Arbor, MI 48108, and **Ian B Hogue**, **Christian J Ray** and **Denise E Kirschner**. *A Methodology For Performing Global Uncertainty And Sensitivity Analysis In Systems Biology.*

Accuracy of results from mathematical and computer models of biological systems is often complicated by the presence of uncertainties in experimental data that are used to estimate parameter values. Current mathematical modeling approaches typically use either single-parameter or local sensitivity analyses. However, these methods do not accurately assess uncertainty and sensitivity in the system as, by default they hold all other parameters fixed at baseline values. Using techniques described within we demonstrate how a multi-dimensional parameter space can be studied globally so all uncertainties can be identified. Further, uncertainty and sensitivity analysis techniques can help to identify and ultimately control uncertainties. In this work we develop methods for applying existing analytical tools to perform analyses on a variety of mathematical and computer models. We compare two specific types of global sensitivity analysis indexes that have proven to be among the most robust and efficient. Through familiar and new examples of mathematical and computer models, we provide a complete methodology for performing these analyses, both in deterministic and stochastic settings, and propose novel techniques to handle problems encountered during this type of analyses. (Received September 16, 2008)

1046-34-1700 **Zahia Drici*** (zdrici@iwu.edu), Illinois Wesleyan University, Department of Math. and Computer Sci., 201 E. Beecher Street, BLOOMINGTON, IL 61701, and **Farzana A. Mcrae** (famcrae@aol.com) and **Vasundhara J. Devi** (vasujdevi@gmail.com). *Fixed-point Theorems for Differential Equations with Causal Operators.* Preliminary report.

In this paper, fixed point theorems for differential equations with causal operators are developed and used to prove some existence results. (Received September 16, 2008)

1046-34-1769 **Brittney N Hinds*** (bxc77740@ucmo.edu), Dept. Mathematics and Computer Science, University of Central Missouri, Warrensburg, MO 64093. *Continuability and Boundedness of Solutions of Differential Equations Without Bounded Assumption on Nonlinear Functions.*

In this talk the continuability and boundedness of solutions for a class of second order nonlinear differential equations $[p(t)f(x'(t))]' = q(t)g(x(t))$ are discussed. Some results of continuability and boundedness of solutions have been obtained in some papers under the boundedness assumption of the function $g(x)$. We consider the continuability and boundedness of solutions without the boundedness requirement of $g(x)$. Therefore, our results have improved some known results. (Received September 16, 2008)

1046-34-1853 **Farzana A. McRae*** (mcrae@cua.edu), Department of Mathematics, The Catholic University of America, Cardinal Station, Washington,, DC 20064, and **J. Vasundhara Devi** (jvdevi@rediffmail.com) and **Zahia Drici** (zdrici@iwu.edu). *Generalized Quasilinearization for Differential Equations with Causal Operators.* Preliminary report.

In this paper the method of generalized quasilinearization is developed for differential equations involving causal operators. (Received September 16, 2008)

1046-34-1915 **Toka Diagana*** (tokadiag@gmail.com), Department of Mathematics, Howard University, 2441 6th Street NW, Washington, DC 20059. *Pseudo Almost Automorphic Solutions to the N-Dimensional Heat Equation with S^p-Pseudo Almost Automorphic Coefficients.* Preliminary report.

In this talk we will establish the existence of pseudo almost automorphic solutions to the N-dimensional heat equation subject to Dirichlet boundary conditions with Stepanov-like-pseudo almost automorphic coefficients. (Received September 16, 2008)

1046-34-1922 **Tyler Y Takeshita*** (tylertak@gmail.com) and **Adrienne Amador** (lafloradesol@gmail.com). *Circuit Approach to Modeling Neurons: New Dynamical Structures and Chaotic Behavior.*

Motivated by Professor Bo Deng's work, a systematic circuit approach to modeling neurons with an ion pump is presented. Like Dr. Deng, the voltage-gated current channels of a neuron are modeled as conductors, the diffusion-induced current channels are modeled as negative resistors, and the one-way ion pumps are modeled as one-way inductors. This model differs from the well-known Hodgkin-Huxley model because it splits the active and the passive branches of each ion species where as the HH approach combines the electromagnetic, diffusive, and pump channels of each ion into one conductance channel. Our model maintains several of the known properties of HH models along with being rich in many new dynamical structures including chaotic behavior. (Received September 16, 2008)

1046-34-2039 **Cesar Martinez Garza*** (cxm58@psu.edu), Penn State Berks, Tulpehocken Road, Reading, PA 19610. *Newton-like Methods for Convex-Concave Functions via the Method of Generalized Quasilinearization.* Preliminary report.

In this paper the Method of Generalized Quasilinearization is used to obtain Newton-like comparative schemes to solve the equation $F(x) = 0$, where $F(x) \in C[\Omega, \mathbb{R}]$, $\Omega = [\alpha_0, \beta_0]$. Here, $F(x)$ admits the decomposition $F(x) = f(x) + g(x)$, where $f(x)$ and $g(x)$ are convex and concave functions in Ω, respectively. We explore the case where $f(x)$ and $g(x)$ are not naturally convex and concave, but are forced by adding the functions $\Phi(x)$ and $\Psi(x)$ where $\Phi_{xx}(x) > 0$ and $\Psi_{xx}(x) < 0$, such that $f_{xx}(x) + \Phi_{xx}(x) \geq 0$ and $g_{xx}(x) + \Psi_{xx}(x) \leq 0$ in Ω. We show the existence of monotone sequences that converge quadratically to the isolated root r of $F(x) = 0$ in Ω. (Received September 16, 2008)

35 ► Partial differential equations

1046-35-6 **Luis A. Caffarelli*** (caffarel@math.utexas.edu). *Non linear problems involving integral diffusions.*

Nonlinear equations with a diffusion component are central to many areas of mathematics and science: fluid dynamics, continuum mechanics, probability, geometry. They quantify the idea that the variable under consideration, U, a temperature, the speed of a flow, a deformation, tries to revert to an "average of itself" in a surrounding infinitesimal neighborhood, resulting in an infinitesimal relation, for instance the heat equation. This averaging effect is what gives elliptic and parabolic equations their stability and regularization properties. In recent years, a lot of interest has surfaced in studying non linear problems where the unknown, U, has global, or at least "non infinitesimal" information, and thus reverts instead to an integral average, giving rise to a non local or integral diffusion equation. Two typical areas where this is encountered is in problems involving surface discontinuities in continuum mechanics (ocean atmosphere interaction, semi permeable membranes, planar crack propagation) and in stochastic processes with jumps (Levy processes), as well as in turbulent flow, material sciences, population dynamics. In this lecture, I plan to describe the type of problems encountered, the difficulties they pose, and give a flavor of the mathematics involved (Received September 07, 2008)

1046-35-9 **James Sethian*** (sethian@math.berkeley.edu), 970 Evans Hall, Department of Mathematics, University of California, Berkeley, Berkeley, CA 94720. *Advances in Advancing Interfaces: Building Semiconductors, Inkjet Plotters, Medical Scanners, and Robotic Devices.*

Propagating interfaces occur in a wide variety of settings, and include ocean waves, burning flames, and material boundaries. Less obvious boundaries are equally important, and include iso-intensity contours in images, handwritten characters, and shapes against boundaries. In addition, some static problems can be recast as advancing fronts, including robotic navigation and finding shortest paths on contorted surfaces.

One way to frame moving interfaces is to recast them as solutions to fixed domain Eulerian partial differential equations, and this has led to a collection of PDE-based techniques, including level set methods, fast marching methods, and ordered upwind methods. These techniques easily accommodate merging boundaries and the delicate 3D physics of interface motion. In many settings, they been proven valuable.

The talk is an overview of this approach, with an eye towards fundamental mathematical ideas and their geometric and algorithmic interpretation. Applications will be framed around industrial engineering collaborations which have led to robust codes for semiconductor manufacturing, inkjet plotters for building plasma displays, image segmentation and tracking in cardiac scanners, robotic navigation, and seismic imaging in oil recovery. (Received September 15, 2008)

1046-35-54 **Eun Kyoung Lee**, **Ratnasingham Shivaji** and **Jinglong Ye*** (jy79@msstate.edu). *Classes of Infinite Semipositone Systems.*

We analyze the positive solutions to classes of nonlinear elliptic systems with Dirichlet boundary conditions, in particular, when the reaction terms tend to $-\infty$ at the origin and satisfy a combined sublinear condition at ∞. We use the method of sub-super solutions to establish our results. (Received July 12, 2008)

1046-35-62 **Patcharin Tragoonsirisak*** (pxt6365@louisiana.edu), Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010. *Quenching phenomena due to a concentrated nonlinear source in $\mathbb{R}^N$.*

This article studies a semilinear parabolic Cauchy problem with a concentrated nonlinear source on the surface of a N-dimensional ball. It is shown that the solution always quenches for $N \leq 2$, and quenching can be prevented for $N \geq 3$. The influence of the source strength on quenching phenomena is discussed. (Received September 01, 2008)

1046-35-101 **Thomas Dean Stephens*** (tstephe3@gmu.edu), 8129 Boss Street, Vienna, VA 22182. *Understanding and predicting materials properties from phase-field simulations.* Preliminary report.

In this talk the interaction of diffusive processes will be explored from the perspective of reaction-diffusion systems arising in materials applications, such as Allen-Cahn and Cahn- Hilliard type models derived from thermodynamic principles. Qualitative behavior of these models and their dynamics will be investigated and numerical simulations will be used to explore the stability of their solutions. Several extensions of these models and their the system morphology and mesoscale behavior will be discussed. (Received July 22, 2008)

1046-35-103 **M R Atkins*** (matkins@gmu,edu). *A numerical and analytical study of modeling techniques for microstructure evolution.*

Microstructural evolution is a phenomenon of paramount importance in various areas of industry; its understanding is critical for designing materials with superior properties. The nonlinear and metastable nature of this mesoscale phenomenon has given rise to various numerical models that attempt to describe it. In this talk we provide a comparison of several computational models that describe microstructure evolution based on their ability to predict statistical properties of different materials. The results of numerical experiments and several extensions of the known modeling techniques are discussed. (Received July 23, 2008)

1046-35-123 **Hongjie Dong*** (hdong@brown.edu), 182 George Street, Providence, RI 02912. *Rigidity of Landau's solutions to the Navier-Stokes equations.*

We consider a special class of solutions of the 3D steady-state Navier-Stokes equations (NSE) by L.D. Landau. These solutions may be calculated explicitly under the assumption of being axi-symmetric and homogeneous of degree -1. By using certain geometrical properties of the 2D sphere, V. Sverak recently proved that even if we drop the requirement of axi-symmetry, Landau's solutions are still the only solutions of NSE which are homogeneous of degree -1.

In this talk, I will show that, i) under a smallness assumption, Landau's solutions are rigid under small perturbations; ii) among smooth vector fields in $\mathbb{R}^3 \setminus \{0\}$ satisfying $|u(x)| \leq C|x|^{-1}$ for sufficiently small $C > 0$, Landau's solutions are the only ones which satisfy (NSE) in $\mathbb{R}^3 \setminus \{0\}$. (Received September 08, 2008)

1046-35-126 **Ronald E. Mickens*** (rohrs@math.gatech.edu), Clark Atlanta University, Physics Department, Box 1744, Atlanta, GA 30314. *Traveling Wave Solutions for a Modified Fisher PDE Having Square-Root and Linear Reaction Terms.*

We investigate a modified Fisher PDE having a reaction term containing both linear and square-root expressions. Our major goal is to study the existence of traveling wave (TW) solutions and to determine their properties if they exist. The major tool for carrying out this task is the application of phase-space methods to this problem. This is possible since a reinterpretation of the second-order ODE determining the functional form of the TW solutions leads to a formulation of the TW equation as a system in particle dynamics. We examine the stability of this solution and construct a dynamical consistent nonstandard finite difference scheme that can be used to calculate numerical solutions.

This work was supported in part by a research grant from DOE and Faculty Professional Development Funds from the CAU School of Arts and Sciences. (Received July 30, 2008)

1046-35-174 **Michael Sever*** (sever@math.huji.ac.il), The Hebrew University, Department of Mathematics, Jerusalem, Israel. *Large-data solution of the Cauchy problem for a model system for singular shocks.*

A modified wave front tracking algorithm is used to find distribution solutions of a pair of conservation laws known as the Keyfitz-Kranzer system or as a model system for singular shocks. As expected, even for smooth, sufficiently large data, singular shocks will appear after finite time. The regular part of the solution, however, is of lower regularity than was anticipated. Locally bounded variation is generally repeatedly lost and regained; we obtain bounds in the space of functions of bounded quadratic variation. (Received August 12, 2008)

1046-35-203 **Silvia Jimenez*** (sjimenez@math.lsu.edu), 4066 Burbank Dr. Apt. 6, Baton Rouge, LA 70808, and **Robert Lipton**. *Local fields in Nonlinear Power Law Materials.*

We focus on strong approximations for local fields in Nonlinear Power Law Materials. The approximations are used to assess the singularity strength inside micro-structured materials. Examples are given for mixtures of different types of power law materials. (Received September 15, 2008)

1046-35-206 **Chadia Affane Aji*** (affane@tuskegee.edu), 2360 Springwood Dr, Auburn, AL 36830, and **A. J. Meir**. *Poroelasticity.*

Poroelasticity is the study of elastic deforming porous materials saturated with a fluid causing a coupling between the fluid pressure and the solid deformation.

This work describes the quasi-static poroelasticity system of partial differential equations consisting of the equilibrium equation for momentum conservation and the diffusion equation for Darcy flow. Using a constructive approach (Rothe's method of lines), we prove the existence and uniqueness of weak solutions to the equations of the quasi-static poroelasticity system. Moreover, numerical methods for solving the poroelasticity system are developed. (Received August 18, 2008)

1046-35-208 **Tunde Jakab*** (tj8y@virginia.edu), Mathematics Department, Kerchof Hall, PO Box 400137, University of Virginia, Charlottesville, VA 22904-4137, **Irina Mitrea**, Mathematics Department, Kerchof Hall, PO Box 400137, University of Virginia, Charlottesville, VA 22904-4137, and **Marius Mitrea**, Mathematics Department, 330 Mathematical Sciences Building, University of Missouri, Columbia, MO 65211. *Sobolev estimates for the Green potential associated with the Robin-Laplacian.*

We show that if $u = G_\lambda f$ is the solution operator for the Robin problem for the Laplacian, i.e. $\Delta u = f$ in Ω, $\partial_\nu u + \lambda u = 0$ on $\partial\Omega$ (with $0 \leq \lambda \leq \infty$), then $G_\lambda : L^p(\Omega) \to W^{2,p}(\Omega)$ is bounded if $1 < p \leq 2$ and $\Omega \subset \mathbb{R}^n$ is a bounded Lipschitz domain satisfying a uniform exterior ball condition. This extends the earlier results of V. Adolfsson, B. Dahlberg, S. Fromm, D. Jerison, G. Verchota, and T. Wolff, who have dealt with Dirichlet ($\lambda = \infty$) and Neumann ($\lambda = 0$) boundary conditions. (Received August 19, 2008)

1046-35-209 **Tunde Jakab*** (tj8y@virginia.edu), Mathematics Department, Kerchof Hall, PO Box 400137, University of Virginia, Charlottesville, VA 22904-4137, **Irina Mitrea**, Mathematics Department, Kerchof Hall, PO Box 400137, University of Virginia, Charlottesville, VA 22904-4137, and **Marius Mitrea**, Mathematics Department, 330 Mathematical Sciences Building, University of Missouri, Columbia, MO 65211. *Differential forms with mixed boundary conditions.*

Let $\Omega \subset \mathbb{R}^n$ be a bounded Lipschitz domain, whose boundary decomposes into two disjoint pieces Σ_t, $\Sigma_n \subseteq \partial\Omega$, which meet at an angle $< \pi$. Denote by ν the outward unit normal to Ω. Then there exists $\varepsilon > 0$ with the property that if $|2-p| < \varepsilon$ then the following holds. Consider a vector field u with components $u_1, ..., u_n \in L^p(\Omega)$ such that $\operatorname{div} u = \sum_{j=1}^n \partial_j u_j \in L^p(\Omega)$ and $\operatorname{curl} u = (\partial_j u_k - \partial_k u_j)_{1\leq j,k\leq n} \in L^p(\Omega)$. Set $\nu \cdot u = \sum_{j=1}^n \nu_j u_j$ and $\nu \times u = (\nu_j u_k - \nu_k u_j)_{1\leq j,k\leq n}$. Then the following are equivalent:

(i) $(\nu \cdot u)\big|_{\Sigma_t} \in L^p(\Sigma_t)$ and $(\nu \times u)\big|_{\Sigma_n} \in L^p(\Sigma_n)$;

(ii) $\nu \cdot u \in L^p(\partial\Omega)$;

(iii) $\nu \times u \in L^p(\partial\Omega)$.

This generalizes earlier work dealing with the case when $\Sigma_t = \emptyset$ or $\Sigma_n = \emptyset$. (Received August 19, 2008)

1046-35-226 **Lisa Termine Hollman*** (Lisa.Termine@trincoll.edu), Trinity College, Department of Mathematics, Hartford, CT. *Existence of Solutions to Semi-linear Elliptic Differential Equations: Approximation and Verification.*

We investigate a conjecture regarding the number of solutions of a second order elliptic boundary value problem with an asymmetric nonlinearity. This investigation makes use of several computer assisted techniques. First we compute approximate solutions using Newton's Iteration for small b and then use a continuation method to show that the number of solutions becomes larger as b increases. Lastly, we discuss how we will use interval arithmetic to show that the exact solution is indeed close to our approximate solution. (Received August 25, 2008)

1046-35-257 **James Glimm***, Dept. of Applied Mathematics & Statistics, SUNY at Stony Brook, Stony Brook, NY 11794. *Compensated Compactness and the Multi-Dimensional Euler Equations.*

Numerical mass diffusion is common in most CFD codes. A numerical code, FronTier, based on front tracking, avoids numerical mass diffusion. It thereby provides a unique insight into turbulent mixing flows.

Numerical evidence is presented to show that some such flows may require measure valued solutions, in the spirit of compensated compactness, for their solution.

Implications for physics as well as for mathematics are discussed. (Received August 24, 2008)

1046-35-268 **Maisa M Khader*** (khader@math.utk.edu), 1160 Kenesaw Ave #A1, Knoxville, TN 37919. *Weighted L^2 Estimates for Dissipative Nonlinear Wave Equations with Space-Time Dependent Potential.*

We studied the long time behavior of solutions of wave equations with absorbtion $|u(t,x)|^{p-1}u(t,x)$ and damping with space-time dependent potential $a(t,x)u_t(t,x)$, where $a(t,x) \sim a_0(1+|x|)^{-\alpha}(1+t)^{-\beta}$ for large $|x|$ and t; $a_0 > 0$. For $\alpha \in (-\infty, 1)$, $\beta \in (-1, 1)$ and $1 < p < (n+2)/(n-2)$ we establish decay estimates for the energy, L^2 and L^{p+1} norms of solutions. We used the new technique developed by Todorova and Yordanov, which is able to capture the exact decay of the wave equations with space dependent coefficients. The presence of a space-time dependent potential, as in our case, requires modifications of this technique.

(1) For exponents α, β such that $\alpha \in (0, 1)$ and $\beta \in (-1, 1)$ and $0 < \alpha + \beta < 1$ we found three different regimes for the decay of solutions dependent on the exponent of the absorbtion term.

(2) In the case $\alpha \in (-\infty, 0]$ and $\beta \in (-1, 1)$ we found one threshold and correspondingly two different regimes for the decay of solutions.

(Received August 24, 2008)

1046-35-269 **Maisa M Khader*** (khader@math.utk.edu), 1160 Kenesaw Ave #A1, Knoxville, TN 37919. *Critical Exponents for Semilinear Wave Equations with Space-Time Dependent Potential.* Preliminary report.

Consider the Cauchy problem for the semi-linear damped wave equations

$$u_{tt} - \Delta u + a(t,x)u_t = |u|^p, \quad x \in \mathbf{R}^n, \quad t > 0, \tag{1}$$

and data in the energy space and compactly supported .
We studied the delicate balance between the time–space dependent potential in the dissipative term and the focusing nonlinearity. We will present sharp critical exponent results, namely to find a critical number p_{cr} such that

- If $1 < p \leq p_{cr}$ the solution blow–up in finite time, regardless of the smallness and smoothness of the initial data.
- If $p_{cr} < p < \frac{n+2}{n-2}$ there exist small data global solutions.

when $a(t,x) \sim a_0(1+|x|)^{-\alpha}(1+t)^{-\beta}$ for large $|x|$ and t; $a_0 > 0$, $\alpha \in [0,1)$, $\beta \in (-1,1)$, the critical exponent is

$$p_c(n,\alpha,\beta) = 1 + \frac{2(\beta+1)}{(n-2)(\beta+1)+2-\alpha}.$$

These results required knowledge of the precise decays rate of the corresponding linear problem with time–space dependent potential, which by itself is very intriguing problem. (Received August 24, 2008)

1046-35-298 **Ryan Sassaman*** (rcsassaman@gmail.com), Department of Mathematics, 1200 N Dupont Hwy, Dover, DE 19901, and **Anjan Biswas** (biswas.anjan@gmail.com), Department of Applied Mathematics and Theoret, Dover, DE 19901. *Soliton perturbation theory for the phi-four equation.*

The soliton perturbation theory is used to study the perturbed phi-four equation. The adiabatic dynamics of the soliton velocity is obtained. (Received August 25, 2008)

1046-35-325 **Ana Vasilic*** (vasilic@math.udel.edu), 213 Ewing Hall, University of Delaware, Newark, DE 19711. *Homogenizing the Acoustics of Cancellous Bone.*

One of clinical methods of screening for osteoporosis and measuring bone density is ultrasound. Although ultrasound has been used to characterize the elastic properties of bone for some time, there is still a need for a better mathematical background for understanding and optimizing the use of this methodology. In this work, mathematical model describing the acoustic behavior of cancellous bone is presented. Bone is approximated by a porous material with periodic micro-structure. The solid part (bone trabeculae) is represented by a visco-elastic porous matrix while the blood-marrow mixture inside the pores is assumed to be a non-Newtonian shear thinning fluid. Using the method of 2-scale convergence, we obtain the equations describing the efective properties of bone capturing the efects of micro-scale. (Received August 26, 2008)

1046-35-383 **Xuming Xie*** (xuming.xie@morgan.edu), Depart of Mathematics, Morgan State University, Baltimore, MD 19713. *Well-posedness in Sobolev space of an unsteady crystal growth problem.* Preliminary report.

We are concerned with an initial value problem arising from dendritic crystal growth with no surface tension. Local existence and uniqueness in Sobolev space are obtained for the problem. (Received August 29, 2008)

1046-35-411 **Myoungjean Bae*** (bae@math.wisc.edu), UW-Madison, Department of Mathematics, 480 Lincoln Dr, Madison, WI 53706, and **Mikhail Feldman**. *Transonic shocks of multi-dimensional compressible flow through divergent nozzles with arbitrary cross-sections.*

In several recent works, the authors proved unique existence and stability of transonic flow with transonic shock for two dimensional Euler system in divergent nozzles when incoming supersonic flow and appropriate exit pressure are prescribed.

In this talk, I will present the same results for multidimensional potential flow through divergent nozzles with arbitrary cross-sections by introducing the non-isentropic potential flow system. Transonic flow governed by this system has a jump of entropy across a shock. I will explain why the non-isentropic potential flow model is necessary to obtain unique existence and stability of transonic shock of multidimensional potential flow in divergent nozzles, and main idea of this work. This is a joint work with Mikhail Feldman (Received September 01, 2008)

1046-35-424 **Nedyu I Popivanov** and **Barbara Lee Keyfitz***, 222 College Street, Toronto, Ontario M5T3J1, Canada. *Self-Similar Multidimensional Conservation Laws: An Excursion into Linear Equations.*

The approach to mutlidimensional conservation laws via self-similar (quasi-steady) solutions typically leads to equations and systems of equations that change type. The reduced equations are hyperbolic in the far field but elliptic or of mixed type near the origin. Change of type occurs either across a transonic shock or at a sonic line, where the equations are of degenerate type. Often the sonic line appears as a free boundary in the formulation of the problem. In this talk, we look at some problems arising from the study of linear Tricomi equations in three dimensions. The mixed-type systems are typically ill-posed. One approach, regularizing by a parameterized family of systems, leads to some partial answers. (Received September 02, 2008)

1046-35-439 **Nathaniel Eldredge*** (neldredge@math.ucsd.edu), UC San Diego, Department of Mathematics, 9500 Gilman Dr., Dept. 0112, La Jolla, CA 92093-0112. *Precise Estimates for the Subelliptic Heat Kernel on H-type Groups.*

H-type groups are a special class of nilpotent Lie groups which generalize the Heisenberg group, and provide a natural setting for the study of second-order partial differential operators which are not elliptic, but only subelliptic. In this talk I will give a brief overview of these objects, and then describe a result which gives precise upper and lower pointwise estimates for the subelliptic heat kernel associated to such a subelliptic operator on an H-type group. (Received September 03, 2008)

1046-35-491 **Florin Catrina*** (catrinaf@stjohns.edu), 150-09 24th Ave, Whitestone, NY 11357. *Loss of Compactness for Nonlinear Elliptic PDE's.*

In this talk we discuss the existence of positive solutions for two families of nonlinear elliptic partial differential equations. We show the nonexistence of positive radial solutions by an energy balance argument, for nonlinear perturbations of two classical ODE's. These arise from the initial equations by symmetry reduction. The sharp cut-off between compactness and non-compactness ranges, help explain in part the role played by critical exponents in elliptic PDE's. (Received September 04, 2008)

1046-35-516 **Yuxi Zheng*** (yzheng@math.psu.edu), Department of Mathematics, University Park, PA 16802. *Mixed type problems and semi-hyperbolic waves in two-dimensional compressible Euler systems.*

We talk about initial-value problems, and in particular Riemann problems, for the Euler system of equations for ideal compressible gases in two space dimensions. The problem allows for self-similar solutions which reduce the independent variables by one. But, the problem becomes hyperbolic-composite elliptic mixed type. We find that between the hyperbolic and elliptic regions, i.e., supersonic and subsonic, the solutions behave rather odd – characteristics exist locally but behave rather like elliptic averaging in the whole. Shock waves appear in the transition zone as well. We follow the nature of the problem and constructed typical patches of such solutions. These are from joint work with several co-workers including Jiequan Li, Xiaomei Ji, Kyungwoo Song, Seunghoon Bang, Mingjie Li, Tong Zhang, Xiaolin Li, Peng Zhang, James Glimm. (Received September 05, 2008)

1046-35-537 **Netra P. Khanal*** (nkhanal@math.okstate.edu), 401 Math Sciences, Department of Mathematics, Oklahoma State University, Stillwater, OK 74078, and **Jiahong Wu**, **Bingyu Zhang** and **Juan-Ming Yuan**. *A study on the solution of complex KdV-Burgers equation.* Preliminary report.

In this talk, we study the series type solutions of the complex KdV-Burgers equation together with complex KdV and complex Burgers equations for a periodic domain and develop a global existence and uniqueness of classical solution if modes of the initial datum are small enough. (Received September 15, 2008)

1046-35-542 **Zhijun George Qiao** and **X Li*** (qiaozjus@yahoo.com), 1201 W Univ Dr, Edinburg, TX 78541. *Peakon Equations.*

We will present some peakon equations that are integrable in the sense of Lax pair. (Received September 07, 2008)

1046-35-555 **G.-Q. Chen**, **J. Chen*** (chenjun@math.uh.edu) and **M. Feldman**. *Transonic flows past wedges governed by full Euler equations.*

Transonic flows arise from various physical phenomena. In this talk, I will focus on the wedge problem. When a supersonic flow past a wedge, there will be a shock created attaching to the tip of the wedge, given some subsonic condition in the far field. I will talk about the existence and uniqueness of this type of flow for 2-D steady Euler equations. For a small perturbation of constant supersonic incoming flow, we can find a unique subsonic flow downstream, which is a small perturbation from a constant subsonic state, and a transonic shock in between. We use implicit function theorem as the framework and delicate elliptic estimates are crucial in this framework. (Received September 08, 2008)

1046-35-581 **Dambaru Bhatta*** (bhattad@utpa.edu), 1201 W University Drive, Department of Mathemtics, The University of Texas-Pan American, Edinburg, TX 78539, and **M. Mallikarjunaiah** and **Daniel Riahi**. *Modeling and Computation of Buoyant Flow during Alloy Solidification.* Preliminary report.

We consider the convective flow in horizontal mushy layer during alloy solidification. During alloy solidification, such mushy layer, which is adjacent the solidification front and is composed of solid dendrite and liquid, is known to produce vertical chimneys that contain convective flow. The convective flow within the chimneys can produce freckles in the final form of the solidified alloy. Freckles are imperfections that reduce the quality of the solidified materials. In the present work we carry out modeling and numerical investigation for different cases of the permeability and interface conditions and for particular parameter values, which cover those of the available experimental studies, to determine the convective flow at the onset of motion. We plan to extend our investigation to cases for controlling the convective flow by including the presence of a vertical magnetic field in the flow system. (Received September 08, 2008)

1046-35-591 **i-kun chen*** (ichen@mail.umd.edu), 7703 Adelphi Rd, Hyattsville, MD 20783. *Spherical Averaged Endpoint Strichartz Estimate for the Two-dimensional Schrödinger Equation with Inverse Square Potential.*

It was proven by T. Tao that the endpoint Strichartz estimates for two dimensional free Schrödinger equation can be recovered by averaging the solution in L^2 in the angular variable. For Schrödinger equation with defocusing inverse square potential, we show that the homogeneous endpoint estimates hold under this setting. In particular, the original versions of these estimates hold for radial data. (Received September 08, 2008)

1046-35-636 **Misha Perepelitsa*** (mikhail.perepelitsa@vanderbilt.edu), 1326 Stenvenson Center, Vanderbilt University, Nashville, TN 37240, and **David Hoff**, 831 East 3rd St, Rawles Hall, Indiana University, Bloomington, IN 47405. *Instantaneous boundary tangency and cusp formation in two-dimensional fluid flows.*

We show that, for solutions of a model of two-dimensional, viscous, compressible fluid flow, curves which are initially transverse to the spatial boundary and across which the fluid density is discontinuous become tangent to the boundary instantaneously in time. We also show by similar techniques that, for the Euler equations of two-dimensional, inviscid, incompressible flow and for a large class of initial data corresponding to vortex patches with corners, these corner singularities become cusp-like instantaneously in time. (Received September 09, 2008)

1046-35-641 **Michael Westdickenberg*** (mwest@math.gatech.edu), School of Mathematics, 686 Cherry Street, Atlanta, GA 30332-0160. *Optimal Transport for the System of Isentropic Euler Equations.*

We introduce a new variational time discretization for the system of isentropic Euler equations. In each timestep the internal energy is reduced as much as possible, subject to a constraint imposed by a new cost functional that measures the deviation of particles from their characteristic paths. We investigate the convergence towards a measure-valued solution and report on numerical experiments for the one-dimensional case.

This is joint work with Wilfrid Gangbo and Jon Wilkening. (Received September 09, 2008)

1046-35-663 **Gui-Qiang Chen** and **Mikhail Feldman*** (feldman@math.wisc.edu). *Shock reflection, free boundary problems, and degenerate elliptic equations.*

We discuss recent work on existence and regularity of solutions to shock reflection problems. (Received September 09, 2008)

1046-35-669 **Monica Torres*** (torres@math.purdue.edu), 150 N. University Street, West Lafayette, IN 47907. *On the structure of solutions of multidimensional systems of conservation laws.*

In this talk we show the existence of strong traces of solutions of multidimensional systems of conservation laws on hyperplanes, assuming a weaker regularity property on the entropy solution. (Received September 09, 2008)

1046-35-677 **Tao Luo*** (tl48@georgetown.edu), Washington, DC 20057, and **Joel Smoller**, Univeristy of Michigan, Ann Arbor, MI. *Stability of Newtonian Rotating White Dwarf Stars.*

In this talk, I will talk about the stability of rotating star solutions for the compressible Euler-Poisson Equations. The rotating star solutions are axi-symmetric steady-state solu- tions of the compressible isentropic Euler-Poisson equations in 3 spatial dimensions, with prescribed angular momentum and total mass. The stability of those solutions is proved by using several conservative quantities, such as mass, energy and angular momentum, for the evolutionary Euler-Poisson equations. Those results apply to white dwarf stars. (Received September 09, 2008)

1046-35-693 **rana durga parshad*** (rparshad@math.fsu.edu), Department of Mathematics, Tallahassee, FL 32306, and **Xiaoming Wang** (wxm@math.fsu.edu), Department of Mathematics, Tallahassee, FL 32306. *On the Uniqueness of Invariant Measures for the Stochastic Infinite Darcy-Prandtl Number Model.*

The infinite Darcy-Prandtl number model is a valid model for convection in porous media at large Darcy-Prandtl number. We study the dynamics of the infinite Darcy-Prandtl number model under stochastic forcing of its low modes. We prove that the system possesses a unique invariant measure under this forcing. (Received September 10, 2008)

1046-35-706 **W E Olmstead** and **Catherine A Roberts*** (croberts@holycross.edu), Dept of Mathematics and Computer Science, =, Worcester, MA 01610. *Thermal Blow-up in a Subdiffusive Medium.*

The problem of thermal blow-up in a subdiffusive medium is discussed within the framework of a fractional heat equation with a nonlinear source term. The analysis will establish that a thermal blow-up always occurs when a finite strip of subdiffusive material is exposed to the effects of a localized, high-energy source such as a laser beam. This behavior is distinctly different from the classical diffusion case in which a blow-up can be avoided by locating the site of the energy source sufficiently close to one of the cold ends of the strip. (Received September 10, 2008)

1046-35-709 **Chunguang Chen*** (cgchen@math.wvu.edu), Department of Mathematics, West Virginia University, Morgantown, WV 26505, and **Harumi Hattori**. *An Accurate Riemann Solver for Euler Equation with Phase Change.*

An accurate Riemann solver is presented for Euler equations with phase change. The phase boundary is assumed to be stationary whereas solutions with moving phase boundaries are treated as perturbations of a stationary one. Entropy condition and kinetic criterion are applied to identify the directions and speeds of the phase boundaries. (Received September 10, 2008)

1046-35-729 **Guy Bernard*** (guy.bernard@mwsu.edu), Department of Mathematics, Midwestern State University, 3410 Taft Boulevard, Wichita Falls, TX 76308. *A Global Existence Theorem for the Navier-Stokes Equations.*

The existence of global solutions in time to the Navier-Stokes equations, filling out all of three dimensional space, is demonstrated with weak decay conditions on the initial-value and its first partial derivatives. The initial-value requires to be twice Holder-continuously differentiable, but not square summable. There are no pointwise boundedness condition on the initial-valuem, but it is required to be bounded by some rational bell-like function. Global regular solutions are established directly using Holder-continuous function spaces, without the intermediate step of weak solutions. The key to this result is the repeated use of symmetry transformations to the Navier-Stokes equations, and the use of appropriate bariers (upper and lower solutions) to the heat operator. (Received September 10, 2008)

1046-35-733 **Monique R Taylor***, 1229 Spruce Dr., Zebulon, NC 27597. *Dafermos regularization of a modified kdV Burgers equation.* Preliminary report.

This project involves Dafermos regularization of partial differential equations of order higher than 2. We show the existence of Riemann-Dafermos solutions near a given Riemann solution using geometric singular perturbation theory. Also we study the stability of Riemann-Dafermos solutions as stationary solutions by means of linearization. (Received September 10, 2008)

1046-35-771 **Liliana Braescu*** (lilianabraescu@balint1.math.uvt.ro), Faculty of Mathematics and Computer Science, West University of Timisoara, Blvd. V Parvan 4, 300223 Timisoara, Romania. *Nonlinear boundary value problem of the meniscus for the terrestrial dewetted Bridgman crystal growth technique.*

Dewetted Bridgman is a crystal growth technique in which the crystal is detached from the crucible wall by a liquid free surface at the level of the solid-liquid interface, called liquid meniscus, which creates a gap between the crystal and the ampoule. Dewetting phenomenon was first obtained spontaneously in spatial experiments, and opened the possibility to reproduce experiments on the earth - obtained by applying a gas pressure difference $\Delta P = P_{cold} - P_{hot}$ between the cold and hot sides of the sample. In order to understand the process which leads to a crystal with a constant radius on the ground, the static stability of menisci is analyzed. For this aim,

starting from the Young-Laplace equation of a capillary surface in equilibrium in the presence of gas pressure, the corresponding nonlinear boundary value problem having three boundary conditions is considered. Because our interest is in the statically stable menisci, the conditions for which the solutions of BVP minimize the total energy functional of the melt column, are searched. In this way, inequalities representing necessary or sufficient conditions for the existence of the convex (or convex-concave) solutions of the considered BVP, are established. Numerical illustrations are given for two semiconductors. (Received September 11, 2008)

1046-35-773 **Katharine Ott*** (kott@ms.uky.edu), Department of Mathematics, University of Kentucky, 719 Patterson Office Tower, Lexington, KY 40506, and **Irinia Mitrea** and **Warwick Tucker**. *The regularity problem for the Lame system of elastostatics on curvilinear polygons in two dimensions.* Preliminary report.

We establish sharp well-posedness results for the regularity problem for the Lamé system of elastostatics in the class of curvilinear polygons in two dimensions. The key technical ingredient is obtaining invertibility properties for the boundary version of the single layer potential operator S associated with the Lamé system acting from $L^p(\partial\Omega)$ onto $L_1^p(\partial\Omega)$, $1 < p < \infty$, whenever Ω is an infinite sector in two dimension of aperture $\theta \in (0, 2\pi)$. Our approach relies on Mellin transform techniques employed to analyze the spectrum of the operator $\partial_\tau S$ on $L^p(\partial\Omega)$, $1 < p < \infty$. (Received September 11, 2008)

1046-35-775 **Anthony N Johnson*** (anthony.johnson@usma.edu), 3032B McDougall Place, West Point, NY 10996. *Development of an unsplit, time dependent, three dimensional elastic perfectly matched layer for elasto-dynamic analyses.*

A time dependent finite element approach to numerically calculating the surface radiation of an elastic wave in half space is presented. The development of the elements require the coupling of a system of linear, second-order, partial differential equations describing elastic wave propagation into a single weak-form (Galerkin) wave equation, from which the characteristics of a composite finite element matching layer are derived. An important problem of interest, and the motivation for this work, is the optimization of a source for use in a seismo-acoustic sonar for the detection of buried mines and improvised explosive devices (IEDs). Various source excitations are presented which maximize the energy of the unidirectional Rayleigh wave while suppressing the energy of associated body waves. The hp-adaptive finite element code SAFE-T (Solid Adaptive Finite Element -Transient), a Finite Element Method (FEM) implementation developed by the author utilizing Altair Engineering's Prophlex kernel, is used to perform the numerical computations. Results for radial and vertical wave strengths are given. This work represents an important step forward in the development of tools needed to pursue applications of seismo-acoustic sonar technology. (Received September 11, 2008)

1046-35-783 **Abbas Momeni*** (momeni@mast.queensu.ca), Jeffery Hall, University Ave, Kingston, Ontario K7L3N6. *A new vaiational principle for Hamiltonian PDEs with nonlinear boundary conditions.*

Selfdual variational calculus is further refined and used to address questions of existence of local and global solutions for various parabolic semi-linear equations, Hamiltonian systems of PDEs, as well as certain nonlinear Schrödinger evolutions. This allows for the resolution of such equations under general time boundary conditions which include the more traditional ones such as initial value problems, periodic and anti-periodic orbits, but also yield new ones such as "periodic orbits up to an isometry" for evolution equations that may not have periodic solutions. In the process, we introduce a method for perturbing selfdual functionals in order to induce coercivity and compactness, while keeping the system selfdual. (Received September 11, 2008)

1046-35-815 **Jintao Cui*** (cui@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Multigrid Solvers for a Class of Discontinuous Galerkin Methods on Graded Meshes.*

In this talk we discuss multigrid solvers for systems resulting from the discretization of second order elliptic boundary value problems by a class of stable and consistent discontinuous Galerkin (DG) methods on graded meshes. Quasi-optimal error estimates in both the energy norm and the L_2 norm for this class of DG methods are derived and uniform convergence of the W-cycle multigrid algorithm for the resulting discrete problem is proved. We will present both theoretical and numerical results. This is joint work with Susanne C. Brenner, Thirupathi Gudi and Li-yeng Sung. (Received September 14, 2008)

1046-35-828 **Zhiren Jin*** (obonly@gmail.com), Department of Mathematics and Statistics, Wichita State University, 1845 N. Fairmount, Wichita, KS 67219. *A Lower Bound for Principal Eigenvalues in Parabola-Shaped Regions.*

When a domain is inside a parabola-shaped region, we show that the principal eigenvlaues for Dirichlet problems of a linear second order elliptic operator in non-divergent form are bounded from below by a positive constant that is independent of the domain. (Received September 11, 2008)

1046-35-842 **Gaston M. N'Guerekata***, 1700 East Cold Spring Ln, Baltimore, MD 21251, and **Alexander Pankov**, 1700 East Cold Spring Ln, Baltimore, MD 21251. *Stepanov-like almost automorphy and monotone evolution equations.*

We inroduce and study classes of Stepanov-like almost automorphic functions with values in a Banach space and study their properties. These classes include the space of Bochner almost automorhic functions and generalize the spaces of Stepanov almost periodic functions. As an application, we present an existence and uniqueness result for solutions of such kind to monotone evolution equations of the form $u'+A(t)u = f(t)$, with Stepanov-like almost automorphic forcing term $f(t)$. (Received September 12, 2008)

1046-35-872 **Jerrold Bebernes*** (bebernes@colorado.edu), 5506 Aztec Ct., Boulder, CO 80303. *Solution Sets for Differential Equations.*

Some examples of solution set properties for various classes of problems for differential equations will be presented. (Received September 12, 2008)

1046-35-908 **Sridevi Pudipeddi*** (pudipedd@augsburg.edu), Mathematics Department, Augsburg College, 2211 Riverside Ave., Minneapolis, MN 55454. *Traveling Wave Solutions for a Nonlinear Equation which Appears in Fluid Dynamics.* Preliminary report.

We look for solutions of $y''' = f_\epsilon(y(t))$ where $f_\epsilon(y) = \frac{(|y-\epsilon)^{\frac{1}{\lambda}}}{y^{1+\frac{2}{\lambda}}} sgn(y-\epsilon)$ and $\epsilon > 0$ which comes up in fluid dynamics. We show for each $\epsilon > 0$ we find a solution which oscillates infinitely often and which goes to ϵ as $t \to \infty$. We also examine the limit of these solutions as $\epsilon \to 0$ and show that the solutions converge to a solution of $y''' = y^a$ where $a = -(1+\frac{1}{\lambda})$. (Received September 12, 2008)

1046-35-926 **Yulia Hristova** (ygh@math.tamu.edu), Mathematics Department, Texas A&M University, College Station, TX 77843-3368, **Peter Kuchment*** (kuchment@math.tamu.edu), Mathematics Department, Texas A&M University, College Station, TX 77843-3368, and **Linh Viet Nguyen** (lnguyen@math.tamu.edu), Mathematics Department, Texas A&M University, College Station, TX 77843-3368. *On singularity reconstruction in thermoacoustic tomography.* Preliminary report.

The talk describes the instability effects arising due to incomplete data or trapping effects in thermoacoustic tomography. A simple microlocal explanation of these effects is provided. (Received September 12, 2008)

1046-35-944 **Nicholas Battista*** (nab4047@rit.edu), School of Mathematical Sciences, 85 Lomb Memorial Drive, Rochester Institute of Technology, Rochester, NY 14623, and **Anthony Harkin** (aahsma@rit.edu), School of Mathematical Sciences, 85 Lomb Memorial Drive, Rochester Institute of Technology, Rochester, NY 14612. *Spectrally Accurate Initial Data for Numerical Relativity.*

Einstein's theory of general relativity has radically altered the way in which we perceive the universe. Einstein's breakthrough was to realize that the fabric of space is deformable in the presence of mass, and that space and time are linked into a continuum. Much evidence has been gathered in support of general relativity over the decades. Some of the indirect evidence for GR includes the phenomenon of gravitational lensing, the anomalous perihelion of mercury, and the gravitational redshift. One of the most striking predictions of GR, that has not yet been confirmed, is the existence of gravitational waves. The primary source of gravitational waves in the universe is thought to be produced during the merger of binary black hole systems, or by binary neutron stars. The starting point for computer simulations of black hole mergers requires highly accurate initial data for the space-time metric and for the curvature. The equations describing the initial space-time around the black hole(s) are non-linear, elliptic partial differential equations (PDE). In this talk, we will discuss how to use a pseudo-spectral (collocation) method to calculate initial puncture data corresponding to both single and binary black hole systems. (Received September 12, 2008)

1046-35-970 **Samuel Rivera*** (samuel.rivera@mavs.uta.edu), 411 S. Nedderman Drive, Pickard Hall, Rm 478, Arlington, TX 76019-0408. *Soliton solutions to the nonlinear Schrödinger equation.*

Solitary wave (soliton) solutions are considered for the nonlinear Schrödinger equation $iu_t + u_{xx} + 2|u|^2u = 0$. Their physical importance is studied, and a Mathematica program is presented producing such multiple soliton solutions and their animations. (Received September 13, 2008)

1046-35-1005 **Joseph L. Shomberg*** (jshomber@providence.edu), Providence College, Department of Mathematics & Computer Science, 227 Howley Hall / Service Building, Providence, RI 02908. *Explicit Construction of a Robust Family of Compact Inertial Manifolds.*

A construction of a robust family of compact inertial manifolds is presented. The result aims to complete an analysis of certain types of attracting sets for a class of dissipative infinite dimensional dynamical systems. Application to a hyperbolically relaxed Chaffee-Infante reaction diffusion equation is also discussed. (Received September 13, 2008)

1046-35-1096 **KO WOON UM*** (kum@math.uiowa.edu), 14 Maclean hall, Iowa city, IA 52242. *Elliptic Equations with BMO Coefficients with singularity in Reifenberg flat Domains.* Preliminary report.

In this talk we consider the inhomogeneous Dirichlet problems concerning divergence form elliptic equation with optimal regularity requirement on the domain. The goal is to obtain $W^{1,p}$ theory allowing the principal coefficient to have singularity along certain subdomain. Our main tools are covering argument, Hardy-Littlewood maximal function and the compactness method. (Received September 14, 2008)

1046-35-1097 **David Chopp*** (chopp@northwestern.edu), ESAM, Tech Institute, 2145 Sheridan Road, Northwestern University, Evanston, IL 60208-3125. *Simulating 3D Fatigue Crack Growth.*

Modeling and simulation of fatigue cracks are important tools in maintaining structures used everyday from bridges to airplanes. These tools are used to estimate the expected lifespan of vital components so that they can be replaced before a catastrophic failure. In this talk, we will describe the use of a combined fast marching method with the extended finite element method (XFEM) to simulate non-planar 3D crack growth. (Received September 14, 2008)

1046-35-1102 **Alex Vladimirsky*** (vlad@math.cornell.edu), 430 Malott Hall, Department of Mathematics, Cornell University, Ithaca, NY 14853-4201. *Causality, dimensionality, efficiency.*

The "direction of information flow" is a natural notion well-defined for a variety of problems, including those in front propagation, optimal control & differential games. "Causal" numerical methods mimic this property of underlying PDEs to ensure the computational efficiency.

One obvious example is time-dependent PDEs where the information flows from the past into the future. Explicit time-marching methods take advantage of the corresponding causal ordering of gridpoints in time-space domains. For boundary value problems, a simple causal approach is to embed the original n-dimensional static problem into R^{n+1} by adding time-dependence, but raising dimensionality also affects the computational cost. Computation of multivalued solutions to first-order PDEs is another problem where the interaction between causality, dimensionality & efficiency is far from trivial. (The original problem in R^n is often restated & solved in a (2n+1)-dimensional phase space.)

We will discuss several problems for which causal methods can be built without increasing the dimensionality & one "static" problem (in multi-objective optimal control) where the increase in dimensionality is natural/unavoidable & the causality of computations is a pleasant side-effect. (Received September 14, 2008)

1046-35-1105 **Ricardo Cortez*** (rcortez@tulane.edu), Department of Mathematics, Tulane University, 6823 St. Charles Ave, New Orleans, LA 70118. *Regularized Stokeslets and other elements with applications to biological flows.*

Biological flows, such as those surrounding swimming microorganisms or beating cilia, are often modeled using the Stokes equations due to the small length scales. The organism surfaces can be viewed as flexible interfaces imparting force on the fluid. I will present the Method of Regularized Stokeslets and other elements that are used to compute Stokes flows interacting with immersed flexible bodies or moving through obstacles. The method treats the flexible bodies as sources of force or torque in the equations and the resulting velocity is the superposition of flows due to all the elements. Exact flows are derived for forces that are smooth but supported in small spheres, rather than point forces. I will present the idea of the method, some of the known results and several examples from biological applications. (Received September 14, 2008)

1046-35-1106 **David Adalsteinsson*** (david@amath.unc.edu), 312 Phillips Hall, Department of Mathematics, UNC Chapell Hill, Chapell Hill, NC 27599. *Coupling Cut cell methods and Level set methods in cellular signaling.*

Biological cells need to be able to sense and responds to their environment. The signaling pathways used to accomplish this represent complex spatial temporal dynamical systems. To study these systems we are developing numerical methods that couple level and cut cell methods to solve a reaction diffusion problem in complex moving geometries. This is work in progress with Wanda Strychalski and Tim Elston. (Received September 14, 2008)

1046-35-1109 **Daniel J Arrigo*** (darrigo@uca.edu), Department of Mathematics, 201 Donaghey Ave., Conway, AR 72035, and **David A Ekrut** and **Jackson R Fliss**. *First order compatibility of the Cubic Schrodinger equation.*

In this talk we consider the compatibility between the nonlinear Cubic Schrodinger equation and a general quasilinear system of partial differential equations (PDEs). Recently it has been proven that the compatibility between PDEs and their associated invariant surface conditions recovers the nonclassical method of symmetry reduction. This can be seen as a generalization of that method. Here we show that two classes of compatible equations exist. The first recovers the results obtainable by the classical symmetry method whereas the second is an entirely new class of compatible equations. We solve this in conjunction with the original system leading to a new reduction of the Cubic Schrodinger equation. (Received September 14, 2008)

1046-35-1118 **Marianna A Shubov*** (marianna.shubov@euclid.unh.edu), Department of Mathematics and Statistics, Kingsbury Hall, University of New Hampshire, Durham, NH 03824, and **Miriam Rojas-Arenaza** (marenaza@cisunix.unh.edu), Department of Mathematics and Statistics, Kingsbury Hall, University of New Hampshire, Durham, NH 03824.
Mathematical Analysis of Double-Walled Carbon Nanotube Model.

In our talk, we present a recently developed mathematical model for a short double-walled carbon nanotube. The model is given as a system of two Timoshenko beams coupled through the Van der Waals force. Mathematically, it is a system of two coupled hyperbolic partial differential equations equipped with a four-parameter family of dynamical boundary conditions. We have reduced the system to an evolution equation with a non-selfadjoint matrix differential operator that is a dynamics generator. Asymptotic and spectral properties of this generator will be present in the talk. We show that it is an unbounded nonselfadjoint operator with compact resolvent. We show that the set of complex eigenvalues of the dynamics generator asymptotically splits into the four individual spectral branches, which is consistent with the physics of the model. We discuss the asymptotical distribution of the eigenvalues along each branch. (Received September 14, 2008)

1046-35-1129 **Diane Denny*** (diane.denny@tamucc.edu), Department of Mathematics and Statistics, Texas A&M University-Corpus Christi, Corpus Christi, TX 78412. *A uniqueness result for equations modeling the flow of a viscous, barotropic fluid under periodic boundary conditions.* Preliminary report.

We study the initial-value problem for a system of nonlinear equations that models the flow of a viscous, barotropic fluid under periodic boundary conditions. The system includes a parabolic equation for the velocity, an algebraic equation (the equation of state) for the pressure as a function of the density, and the equation $\nabla \cdot \mathbf{v} = 0$. We prove the existence of a unique classical solution $\rho(\mathbf{x}, t)$, $\mathbf{v}(\mathbf{x}, t)$ for the time interval $0 \leq t \leq T$, provided $\|D\mathbf{v}_0\|_s$ is sufficiently small, where $\mathbf{v}_0$ is the initial velocity data. The density ρ satisfies $\rho(\mathbf{x}_0, t) = \rho_0(\mathbf{x}_0, t)$ at a chosen point $\mathbf{x}_0$ in the domain, where ρ_0 is the initial iterate for an iteration scheme. (Received September 14, 2008)

1046-35-1186 **Konstantina Trivisa*** (trivisa@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *On the dynamics of multicomponent reactive flows.*

Multicomponent reactive flows arise in many physical applications in sciences and engineering such as combustion, atmospheric modeling, astrophysics, chemical reactions, mathematical biology. The objective of this work is to develop a rigorous mathematical theory based on the principles of continuum mechanics. Issues of existence, asymptotic analysis, stability and compressible-incompressible limits are addressed. (Received September 15, 2008)

1046-35-1209 **C David Levermore*** (lvrmr@math.umd.edu), Department of Mathematics, Bldg 084, University of Maryland, College Park, MD 20742, and **Weiran Sun** (wrsun@math.umd.edu), Department of Mathematics, Bldg 084, University of Maryland, College Park, MD 20742. *Local Well-Posedness of a Dispersive Navier-Stokes System.*

We establish local well-posedness and smoothing results for the Cauchy problem of a degenerate dispersive Navier-Stokes system that arises from kinetic theory. Under assumptions that the initial data satisfy asymptotic flatness and non-trapping conditions, we show there exists a unique classical solution for a finite time. Due to degeneracies in both dissipation and dispersion for the system, different components of the solution gain different regularity. The coupling of these components is analyzed using pseudodifferential operators. (Received September 15, 2008)

1046-35-1284 **Jae-Seok Huh*** (jshuh@acm.caltech.edu), 207 Firestone, Applied and Computational Math, California Institute of Technology, MC 217-50, 1200 E. California Boulevard, Pasadena, CA 91125. *Exact subgrid interface correction (ESIC) schemes for elliptic interface problems.*

We present the ESIC, a non-conforming finite element method for second order elliptic interface problems, where discontinous coefficients and singular sources on the interface may give rise to jump discontinuities in either the solution or its normal derivative.

The ESIC satisfies the prescribed jumps by recasting the given singular problem into a regular problem with additional correction sources on the right-hand-side; these are solved on a fixed background mesh providing accurate subgrid resolution of the discontinuities.

To construct this correct function, we utilize closest point extensions and an implicit interface signed distance function representation; the resulting function is supported only on the interface elements, represented by the regular basis functions, and bounded independently of the interface location with respect to the background mesh. For a constant second-order coefficient, the singular function regularization is straightforward, and the resulting left-hand side is an instability-free regular problem. The influence of the regularization appears solely on the right-hand side. For more general discontinuous second order coefficients, a normalization is invoked which introduces a constraint equation on the interface. (Received September 15, 2008)

1046-35-1296 **Jenny Suckale*** (suckale@mit.edu), Office 54-617, MIT, Massachusetts Ave 77, Cambridge, MA 02139, and **J.C. Nave** and **B.H. Hager**. *How to make the most out of level sets for geodynamical modeling.*

A key challenge in geodynamical modeling is to represent interfaces between different fluids in 2D and 3D, such that (1) no restrictions on the interface deformability are imposed, (2) mass is conserved, and (3) discontinuous jumps in fluid properties at the interface are maintained. We present a new level set approach, providing efficiency, robustness, accuracy, and topological change. A key aspect of our algorithm is an extension velocity approach, accurately coupling flow dynamics to the interface, and avoiding spurious mass loss and artificial front repositioning that plague reinitialization schemes. A new scheme for Stokes equation in a ghost fluid setup is presented, obviating the need for smoothing of sharp discontinuities: interfaces are represented sharply with sub-grid interpolation. Correct flow fields are computed, even in the presence of huge and discontinuous jumps in material parameters, such as viscosity contrasts of several orders of magnitude. We study several geodynamical problems, and validate our code by reproducing the benchmarks for the isothermal Rayleigh-Taylor instability by van Keken et al. 1997. We compare our approach to particle, marker, and color function methods, detailing advantages and demonstrating complex structures in evolving flows. (Received September 16, 2008)

1046-35-1305 **Abhinandan Chowdhury*** (axc3435@louisiana.edu), 200 Oakcrest Drive, Apt No. E-254, Lafayette, LA 70503. *Perturbation of a Gradient Temperature Field due to the Presence of Two Spheres.* Preliminary report.

In micro-level studies of properties of multi-component media, the additions to the effective transport coefficient proportional to the first order of concentration connected with the solution of Laplace equation with linear gradient at infinity in infinite domain containing a sphere of different conductivity is known as “one-sphere solution”. The second order in concentration effects for the overall transport coefficients can be estimated if the solution of the Laplace equation with linear gradient at infinity is found in an infinite domain containing two non-overlapping spheres with different transport coefficient. Our objective is to solve the two-sphere problem by using a rapidly converging spectral method. By using bi-spherical coordinates, the solution is expanded in series of Legendre polynomials and a numerical method is developed to solve the system for the coefficients. The specific difficulties connected with the spectral expansion are overcome and the solution is found for different

configurations of the spheres regarding the linear gradient at infinity. This solution is valid for any arbitrary distance between the spheres. (Received September 15, 2008)

1046-35-1306 **Adam Oberman*** (aoberman@sfu.ca), SC K10540, Mathematics Department, Simon Fraser University, 8888 University Drive, Burnaby, B.C. V5A 1S6, Canada. *Front propagation in three scale media.*

We study the propagation of fronts in media with three scales: a macro scale, on which a slow parameter varies, a microscale on which some form of homogenization is required to effectively solve the equations, and a mesoscale on which the homogenized materials vary slowly. We used a vectorgram based approach to record effective speed on the mesoscale, and a specialized more efficient homogenization technique.

Even in simple situations where the speeds are varying periodically (e.g. checkerboard, stripes) the resulting homogenized speeds are non-Riemannian. So computing the solution to the macroscale problems requires the use of general front propagation solvers. (Received September 15, 2008)

1046-35-1374 **August Johansson*** (august.johansson@math.umu.se), Department of Mathematics, Umea University, SE-901 87, Umea, Sweden. *A Finite Element Method for Implicit Interface Problems.*

Interface problems involve differential equations containing discontinuous data and solutions across some interface. If the interface evolves it is desirable to be able to track it without remeshing. Here, we present a finite element method for handling elliptic problems where discontinuous coefficients and singular sources are the causes of jumps in the solution or in its normal derivative. A level set formulation is used for the representation of the interface. The method is general in the sense that there is no special consideration to be made regarding dimension or element type.

The method was first developed by Huh and Sethian for 2D static problems. It relies on constructing correction functions corresponding to the prescribed jumps. In the case of constant coefficients, implementation is facilitated by the result that the corrections only appear in the right hand side of the equation. In this paper, we extend the method to three dimensions, and couple it to moving interface problems under complex physics. This is illustrated in a three-dimensional combustion problem on a hexahedral mesh. By allowing for discontinuous coefficients, the method is generalized to a fully nonconforming finite element method. (Received September 15, 2008)

1046-35-1408 **Adrian Nachman**, Dept. of Mathematics, Toronto, Ontario , Canada, **Alexandru Tamasan*** (tamasan@math.ucf.edu), Dept. of Mathematics, 4000 Central Florida Blvd., Orlando, FL 32816, and **Alexandre Timonov**, Division of Mathematics and Computer Science, Spartanburg, SC. *Current Density based Electrical Impedance Tomography.*

This talk introduces a new hybrid method for conductivity imaging. The method uses one measurement of the magnitude of the current density field. The problem can be reduced to a non-smooth variational question. (Received September 15, 2008)

1046-35-1416 **Arian Novruzi*** (novruzi@uottawa.ca), Department of Mathematics, University of Ottawa, 585 King Edward Avenue, Ottawa, ON K1N 6N5, Canada, and **Al-Arydah Mo'Tassem**. *Existence of positive solutions to a nonlinear PDE system, modeling fuel cell dynamics near a triple phase boundary*

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We consider a 2d PDE nonlinear system coupling two variables in three different domains: vapour in a 2d air domain (air pore) and water in 2d porous domain (ionomer) and in a 1D domain. It is a simplified version of a mathematical model representing the distribution of gases near a triple phase boundary in catalyst layer of hydrogen fuel cells, in undersaturated regime.

To note that the system involves singular boundary data which couple the diffusion between 2d and 1d domains. Furthermore, the 1d equation is a limit of a reaction-diffusion-migration equation in a thin 2d domain, when the width of the domain tends to zero.

Under precise conditions on boundary data, we establish several a priori estimates, and we prove the existence of a positive solution following a fixed point argument.

Finally we consider numerically the validity of our model by comparing the solution of our limit model (involing 1d equation) with the original one which instead involves a thin 2d domain. (Received September 15, 2008)

1046-35-1426 **Bao-Feng Feng*** (feng@utpa.edu), 213 E Baylor Ave, McAllen, TX 78504, and **Yasuhiro Ohta** and **Ken-ichi Maruno**. *Bilinear equations, integrable semi-discretization, and novel numerical computations of the Camassa-Holm equation.*

The Camassa-Holm (CH) equation has attracted considerable interest since it was derived as a model equation for shallow-water waves. The CH equation is shown to be completely integrable, admitting non-smooth solutions such as peakon and cuspon solutions. However, it is extremely difficult to perform numerical computations of the CH equation due to the singularities of the solutions. So far, none of the numerical methods for the CH equations gives a satisfactory result.

From a reduction of KP-Toda hierarchy, we first give bilinear equations directly related to the CH equation. Then, we propose an integrable semi-discrete CH equation. Determinant formulas for multi-soliton solutions of the continuous and semi-discrete CH equations are presented, from which smooth soliton and cuspon soliton solutions for both continuous and semi-discrete CH equations can be generated. From the point view of numerical analysis, a novel numerical method, i.e., a self-adaptive method is implied from the semi-discrete CH equation for the numerical computations CH equation. The results of numerical simulations are very surprising, showing very accurate numerical solutions for the soliton-solition and cuspon-cuspon interactions by using coarse grid points. (Received September 15, 2008)

1046-35-1453 **Koffi B Fadimba*** (Koffif@usca.edu), University of South Carolina Aiken, 471 University Parkway, Aiken, SC 29801. *Immiscible Two-Phase Flow Through Porous Media: A Case of Uniqueness of a Solution.* Preliminary report.

Uniqueness of a solution for the pressure/saturation system

$$\begin{cases} \mathbf{u} = -a(S)\nabla p & \text{in } \Omega \times (0,T) \\ \nabla \cdot \mathbf{u} = Q_1 & \text{in } \Omega \times (0,T) \\ \phi \dfrac{\partial S}{\partial t} + \nabla \cdot (f(S)\mathbf{u} - k(S)\nabla S) = Q(S) & \text{in } \Omega \times (0,T) \end{cases} \tag{1}$$

has been proved under conditions that seem rather strong. In this paper we exhibit an example of permeabilities for which some of these conditions are satisfied. We also show that, in this case, the solution of the often considered regularization problem converges to the solution of the initial problem. (Received September 15, 2008)

1046-35-1492 **Qingshan Chen*** (qinchen@indiana.edu), Department of Mathematics, Rawles Hall, Bloomington, IN 47403, and **Roger Temam**. *Accurate resolution of a nonlinear PDE with corner singularities.* Preliminary report.

For the solution of an initial-boundary value problem to be smooth near the origin, it is necessary and sufficient that the initial conditions and the boundary conditions satisfy some compatibility conditions, in general, if the solution exists. The number of necessary compatibility conditions depends on the desired regularity (up to infinitely many conditions). When these compatibility conditions are not satified, corner singularities will occur in the solution near t = 0, which may cause a severe loss of numerical accuracy. In this talk we will present a remedy procedure valid in principle for general equations, but for clarity we will restrict ourselves to the viscous Burger's equation, and we will show how to numerically handle the first two and most important singularities and thus improve the numerical accuracy. This is a joint work with Roger Temam. (Received September 16, 2008)

1046-35-1619 **Robin C Young*** (young@math.umass.edu), Mathematics and Statistics, University of Massachusetts, Amherst, MA 01035, and **J Blake Temple**. *On Shock-Free Periodic Solutions for the Euler Equations.*

We consider the existence of periodic solutions to the Euler equations of gas dynamics. Such solutions have long been thought not to exist due to shock formation, and this is confirmed by the celebrated Glimm-Lax decay theory for 2x2 systems. However, in the full 3x3 system, multiple interaction effects can combine to slow down and prevent shock formation. In this talk I shall describe the physical mechanism supporting periodicity, describe combinatorics of simple wave interactions, and develop periodic solutions to a "linearized" problem. These linearized solutions have a beautiful structure and exhibit several surprising and fascinating phenomena. I shall also discuss partial progress on the perturbation problem: this leads us to problems of small divisors and KAM theory. (Received September 16, 2008)

1046-35-1694 **Karen Daniels** and **Lindsay B.H. May*** (lbhilber@ncsu.edu), North Carolina State University, Box 8205, Raleigh, NC 27695, and **Kasey Phillips** and **Michael Shearer**. *A model for particle size segregation in granular flow under nonuniform shear.*

A hyperbolic conservation law in one space variable and time describes particle size segregation in the presence of nonuniform shear. This PDE generalizes the Savage-Lun (1988) and Gray-Thornton (2005) models of segregation in granular avalanches, which assume uniform shear. Size segregation is observed in a Couette cell experiment in which a bidisperse mixture of spherical glass beads is sheared by rotating the bottom boundary. Experimental results are compared to analysis of the PDE model. (Received September 16, 2008)

1046-35-1699 **Ali Kemal Unver*** (aunver@asu.edu), Department of Mathematics and Statistics, Arizona State University, P.O. Box 871804, Tempe, AZ 85287-1804. *Observation Based PDE Models for Stochastic Production Systems.* Preliminary report.

Fast methodologies for predicting complex re - entrant manufacturing systems and supply chains are developed. The basic idea underlying the approach is to extract 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). The work carries the promise to create an almost universally applicable tool to provide rough estimates of the behavior of complex production systems in non - equilibrium regimes. (Received September 16, 2008)

1046-35-1703 **Joao Ricardo Branco*** (info@isec.pt), Rua Pedro Nunes - Quinta da Nora, 3030-199 Coimbra, Portugal, **Jose Augusto Ferreira** (comct@mat.uc.pt), Largo D. Dinis, Apartado 3008, 3001 – 454 Coimbra, Portugal, and **Pascoal Martins Silva** (info@isec.pt), Rua Pedro Nunes - Quinta da Nora, 3030-199 Coimbra, Portugal. *Non-Fickian delay reaction-diffusion equations : theoretical and numerical study.*

The Fisher's equation is established combining the Fick's law for the flux and the mass conservation law with a reaction term evaluated at the present time. If this term depends on the solution at some past time, a delay parameter is introduced and the delay Fisher's equation is obtained. Modifying the Fick's law for the flux considering a time memory term, integro-differential equations of Volterra type are established.

In this work we study reaction-diffusion equations obtained combining the two modifications: a time memory term in the flux and a delay parameter in the reaction term. The delay integro-differential equations also known as delay Volterra integro-differential equations, are studied in the theoretical view point: stability estimates are established. Numerical methods which mimic the theoretical models are analysed. Numerical experiments illustrating the established results are also included. (Received September 16, 2008)

1046-35-1828 **Ana Vasilic*** (vasilic@math.udel.edu), University of Delaware, Dept. of Mathematical Sciences, 213 Ewing Hall, Newark, DE 19716, and **Ming Fang** and **Robert P. Gilbert**. *Homogenization of Time-Harmonic Acoustics of Bone: The Diphasic Case.*

Osteoporosis can be described as a decrease in strength of bone. One of the non-invasive screening techniques for osteoporosis is ultrasound. Although this method has been used to characterize the acoustic properties of bone for some time, there is still a need for better mathematical models which would lead to improved interpretation of ultrasound tests. We present a mathematical model of time-harmonic acoustics of cancellous bone. Bone is modeled as a porous medium with periodic arrangement of pores of characteristic size ε. The solid part (the bone matrix) is assumed to be elastic and the pores contain a slightly compressible viscous fluid (representing blood-marrow mixture). We consider the effective diphasic behavior corresponding to the case when fluid and solid move out-of-phase. To obtain the effective equations (describing homogenized behavior of the medium) we employ the two-scale convergence method. For sufficiently small frequency of time-harmonic waves, we prove that there exist unique solution to the homogenized two-scale system. Moreover, after introducing several auxiliary problems on the unit cell, we eliminate the fast variable from the equations for the displacement. (Received September 16, 2008)

1046-35-1850 **Patricia E. Bauman**, Department of Mathematics, Purdue University, West Lafayette, IN 47906, and **Zhenqiu Xie*** (xie2@purdue.edu), Department of Mathematics, Purdue University, West Lafayette, IN 47906. *Minimizers of the Lawrence-Doniach Model for Superconductors under Weak Coupling and a Parallel or Slightly Tilted Field.* Preliminary report.

We consider minimizers to the Lawrence-Doniach energy for superconductors with coupled layer structures. When the exterior magnetic field is parallel or slightly tilted to the layers and the Josephson coupling between layers is small, we prove that the global minimizer has no vortices on layers. Using Lyapunov-Schmidt techniques, we express the minimizing state as a C^1 function of the coupling constant and the applied magnetic field. We also prove stability and obtain detailed information on the nature of the order parameter on each layer and the induced magnetic field in this case. Our results show that in this setting, even in large magnetic fields, stable solutions without vortices can occur. In this case, the order parameter is non-uniform in each layer, but has a nearly uniform phase jump between adjacent layers. (Received September 16, 2008)

1046-35-1851 **TAEWAN PARK*** (tae-wan.park@millersville.edu), 1505 Butter road APT6, Lancaster, PA 17601. *The physical model of a Variational Nonlinear Wave Equation.*

We analyze the existance of smooth global solutions of a variational nonlinear wave equation which originates from the modeling of orientation waves in a massive nematic liquid crystal director field. We prove that the equation has the global solution in higher space dimension and smooth solutions develop singularities in finite time in one space dimension. And also gave the physical model of a Variational Nonlinear Wave Equation in higher space dimension. (Received September 16, 2008)

1046-35-1925 **Kyle S Hickmann*** (hickmank@math.oregonstate.edu), Department of Mathematics, Kidder Hall 368, Oregon State University, Corvallis, OR 97331. *The Unique Determination of an Acoustic Speed from Thermoacoustic Tomography Data.*

A new result pertaining to a mostly unexplored uniqueness question in thermoacoustic tomography is presented. We demonstrate a partial answer to the question, If $u_1(x,t)$ and $u_2(x,t)$ satisfy

$$\begin{aligned}\partial_t^2 u_1 - c_1^2(x)\Delta u_1 &= 0 \text{ in } \mathbb{R}^n \times \mathbb{R}_+\\ \partial_t^2 u_2 - c_2^2(x)\Delta u_2 &= 0 \text{ in } \mathbb{R}^n \times \mathbb{R}_+\\ u_1(x,0), u_2(x,0) &\in C_0^\infty(D),\\ \partial_t u_1(x,0) = 0 &= \partial_t u_2(x,0) \text{ in } \mathbb{R}^n\\ u_1(x,t) &= u_2(x,t) \text{ on } \partial D \times \mathbb{R}_+\end{aligned}$$

then is $c_1(x) = c_2(x)$ in D? Here $D \subset \mathbb{R}^n$ is bounded, convex and the acoustic speeds are assumed to be smooth and equal to 1 outside of D with $c_1(x) - c_2(x) \geq 0$ in D. Also, it is assumed that one of the sound speeds is non-trapping and the dimension n is odd. In this case we can conclude that $u_1(x,0) = u_2(x,0)$ in D as well. We use the relation of the wave equation to the Helmholtz equation and decay estimates for the wave equation to show that uniqueness of the sound speed is connected to the interior transmission problem. (Received September 16, 2008)

1046-35-1966 **Russell L Herman*** (hermanr@uncw.edu), Mathematics and Statistics, UNC Wilmington, Wilmington, NC 28403. *Propagation of Solitons Under Colored Noise.* Preliminary report.

How is the evolution of special solutions, such as solitons and solitary waves, affected by colored noise? We review the known behavior of stochastic solitons under white noise and describe preliminary numerical results for colored noise. (Received September 16, 2008)

1046-35-1979 **Taufiquar Khan**, **Peter Maass** and **Bonnie McAdoo*** (bonniem@clemson.edu). *Using Distinguish-ability Criteria to Optimally Design Sources in Optical Tomography.*

In this paper, we formulate a min-max optimal source design problem in optical tomography. We propose an algorithm to compute the optimal source by maximizing a distinguish-ability criteria for a given set of optical parameters. To find the optimal source, we compute the eigenfunction corresponding to the maximum eigenvalue of a linear operator A that maps $L^2(\partial\Omega)$ or $H^{-1/2}(\partial\Omega)$ to $L^2(\Omega)$ or $H^1(\Omega)$. Therefore the optimal source depends on the choice of the pairs of the function spaces used. We devise algorithms for different choices of these function space pairs and compare the solutions corresponding to these pairs in terms of the distinguish-ability criteria. (Received September 16, 2008)

1046-35-1982 **Yang Li*** (yangli3@msu.edu), Dept. of Mathematics, 212A Wells Hall, Michigan State University, East Lansing, MI 48824, and **Keith S Promislow** (kpromisl@math.msu.edu), Department of Mathematics, 212A Wells Hall, East Lansing, MI 48864. *Gamma convergence for Functionalized Energies.* Preliminary report.

An essential element of energy conversion is the development of interconnecting networks of nanometer scale conductive materials. For these materials to be cost effective they must be self-assembling. One method to attain this is to functionalize hydrophobic polymers by the addition of pendant acid tipped side-chains. When mixed with solvent the materials phase-separate into pore structures. We model this with an energy which corresponds to square curvature of the interface *minus* surface area, which we call the functionalization of surface area. Minimizers of the energy seek to maximize surface area while minimizing curvatures. We extend the concept of functionalization to a broad class of convex energies and show that the resulting Gamma-convergence problems lead to a novel higher-order curvature driven flows. (Received September 16, 2008)

1046-35-2013 **Margot Gerritsen*** (margot.gerritsen@stanford.edu), Green Earth Sciences Building, 367 Panama street, Stanford, CA 94305, and **J V lambers** and **Z Zhu**. *Performance prediction of thermal recovery processes, or how we can produce heavy oil in an environmentally friendly way.*

As easy to produce oil reserves are decreasing, we are increasingly relying on heavy oil and other nonconventional oil resources. These include the Canadian tar sands and shale oils in the Rockies, as well as large heavy oil reserves in Venezuela. Production techniques rely on heating to mobilize these very viscous fluids, which results in large carbon footprints. Moreover, heavy oil brought to the surface generally contains components that are undesirable. Cleaner production alternatives that are now intensely researched by the oil industry and in academics include in-situ combustion. In this recovery process, part of the oil is burned in place to create a subsurface steam flood that helps drive the oil to the producing wells. Prediction of in-situ combustion is exceedingly challenging. In this talk I will discuss the process and present the outstanding mathematical and numerical problems. (Received September 16, 2008)

1046-35-2065 **Ravi Srinivasan*** (rav@dam.brown.edu), Division of Applied Mathematics, Brown University, 182 George St., Providence, RI 02912. *Complete integrability in Burgers turbulence.* Preliminary report.

Decaying Burgers turbulence (1-D Burgers equation with random initial data) is a fundamental example of a nonlinear system out of equilibrium with wide applicability as a model of coarsening through particle coalescence. Shocks that generically develop due to the nonlinearity serve the role of particles that interact through ballistic aggregation as the system coarsens. More generally one can consider the initial value problem for the 1-D scalar conservation law

$$\partial_t u + \partial_x f(u) = 0$$
$$u(x,0) = u_0(x)$$

with $u_0(x)$ a stochastic process indexed by x (which can be interpreted a random field in one dimension). Previous work with the Burgers flux include results for u_0 a spectrally negative Levy process and a highly nontrivial explicit solution for Gaussian white noise initial data. Both of these can be regarded as limit cases with $u_0(x)$ a stationary, spectrally negative Markov process, for which we show the entropy solution $u(x,t)$ to the conservation law remains in this class. Furthermore, we demonstrate that the evolution of the infinitesimal generator of the solution process has the remarkably simple form of a Lax pair. (Received September 17, 2008)

1046-35-2087 **Thaleia Zariphopoulou*** (zariphop@math.utexas.edu), RLm C1200, Austin, TX 78712, and **Marek Musiela** (marek.musiela@bnpparibas.com), 10 Harewood Avenue, London, England. *Portfolio choice under space-time monotone performance criteria.*

I will discussed the optimal investment problem of an investor with space-time monotone criteria. This case corresponds to the choice of zero volatility in the forward performance spde. Explicit solutions for the optimal wealth and optimal portfolio processes will be provided. The important question how to infer the investor's preferences from his/her desired target wealth distribution will be also discussed. (Received September 17, 2008)

1046-35-2125 **Yuri Latushkin*** (yuri@math.missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211. *Stability of a combustion front*

For gasless combustion in a one-dimensional solid, we show a type of nonlinear stability of the physical combustion front. This is a joint project with Anna Ghazaryan, Stephen Schecter, and Aparecido J. de Souza. (Received September 25, 2008)

1046-35-2127 **Michael E. Filippakis*** (mfilip@math.ntua.gr), National Technical University of Athens, Department of Mathematics, Zografou Campus, 15780 Athens, **Ravi P. Agarwal**, Department of Mathematical Sciences, Florida Institute of Technology, Melbourne, FL 32901-6975, **Donal O'Regan**, Department of Mathematics, National University of Ireland, Galway, and **Nikolaos S. Papageorgiou**, National Technical University of Athens, Department of Mathematics, Zografou Campus, 15780 Athens. *Nodal and multiple constant sign solutions for the p-Laplacian* Preliminary report.

We consider nonlinear elliptic equations driven by the p-Laplacian with a nonsmooth potential (hemivariational inequalities). We obtain the existence of multiple nontrivial solutions and we determine their sign (one positive, one negative and the third nodal). Our approach uses nonsmooth critical point theory coupled with the method of upper-lower solutions. Research supported by a grant of the National Scholarship Foundation of Greece (I.K.Y.). (Received September 26, 2008)

37 ► Dynamical systems and ergodic theory

1046-37-2 **Gregory Margulis*** (Margulis@math.yale.edu), Yale University, Department of Mathematics, P.O. Box 208283, New Haven, CT 06520-8283. *Homogeneous dynamics and number theory I.*

Homogeneous dynamics is another name for the theory of flows on homogeneous spaces, or homogeneous flows. The study of homogeneous flows has been attracting considerable attention for the last 40-50 years. During the last three decades, it has been realized that some problems in number theory and, in particular, in Diophantine approximation, can be solved using methods from the theory of homogeneous flows. The purpose of this lecture is to give examples of the interaction between number theory and the theory of homogeneous flows. Mostly only formulations will be given, but there will be also very brief description of some proofs. (Received September 12, 2008)

1046-37-3 **Gregory Margulis*** (margulis@math.yale.edu), Yale University, Department of Mathematics, P.O. Box 208283, New Haven, CT. *Homogeneous dynamics and number theory II.*

It will be the continuation, on a more technical level, of the first lecture. Topics to be (very briefly) covered include: (1) recurrence to compact sets and Diophantine approximation on manifolds; (2) orbit closures, the Oppenheim conjecture and the Littlewood conjecture; (3) classification of ergodic invariant measures and equidistribution; (4) quanttitative Oppenheim conjecture and counting of integral points on homogeneous varieties. (Received September 14, 2008)

1046-37-4 **Gregory Margulis*** (margulis@math.yale.edu), Yale University, Department of mathematics, P.O. Box 208283, New Haven, CT. *Homogeneous dynamics and number theory III.*

A sketch of the proof of the Oppenheim conjecture will be given. Other topics to be mentioned include: (1) different approaches to the quantitative Oppenheim conjecture; (2) effective equidistribution; (3) homogeneous dynamics and geometry of numbers. (Received September 14, 2008)

1046-37-52 **Hongkun Zhang*** (hongkunz@gmail.com). *Decay of correlations of nonuniform geodesic flows.* Preliminary report.

This is a joint work with Keith Burns. The study of decay of correlations for nonuniform suspension flows starts from Melbourne around 2006. In this paper, we consider the geodesic flows on surfaces with nonpositive curvature. We constructed a cross section in the phase space and first estimate the mixing rate for the Poincare map following the general approach for studying systems with singularities. Then by applying Melbourne's Theorem and we obtain the polynomial decay rates for the flow. (Received July 10, 2008)

1046-37-82 **Joshua Brandon Holden*** (holden@rose-hulman.edu), CM#125, 5500 Wabash Ave., Terre Haute, IN 47803. *Braids, Cables, and Cells: An intersection of Mathematics, Computer Science, and Fiber Arts.* Preliminary report.

The mathematical study of braids combines aspects of topology and group theory to study mathematical representations of one-dimensional strands in three-dimensional space. These strands are also sometimes viewed as representing the movement through a time dimension of points in two-dimensional space. On the other hand, the study of cellular automata usually involves a one- or two-dimensional grid of cells which evolve through a time dimension according to specified rules. This time dimension is often represented as an extra spacial dimension. Therefore, it seems reasonable to ask whether rules for cellular automata can be written in order to produce depictions of braids. The ideas of representing both strands in space and cellular automata have also been explored in many artistic media, including knitting and crochet, where braids are called "cables". We will view some examples of braids and their mathematical representations in these media. (Received September 15, 2008)

1046-37-116 **Annalisa Crannell*** (annalisa.crannell@fandm.edu), Department of Mathematics, Box 3003, F&M, Lancaster, PA 17604. *Quasicontinuous functions in dynamical systems.*

We present quasicontinuous functions as a "natural" class of functions to bridge the various notions of topological, measure-theoretic, and computational dynamics. This class includes many commonly studied classes of discontinuous maps (piecewise expanding, interval exchange, *etc.*) and we show that these functions have fundamental connections to closed relations. We present results on the properties of iterated quasicontinuous maps and present hypotheses under which the Krylov-Bugolyubov theorem (existence of an invariant measure) holds. (Received July 25, 2008)

1046-37-136 **Gaofei Zhang*** (zhanggf@hotmail.com), Department of Mathematics, Nanjing University, Nanjing, Jiangsu 210093, Peoples Rep of China. *All bounded type Siegel disks of rational maps are quasi-disks.*

We prove that every bounded type Siegel disk of a rational map must be a quasi-disk with at least one critical point on its boundary. This implies that Douady-Sullivan's conjecture holds for bounded type Siegel disks and generalizes the previous result of Shishikura from polynomial maps to all rational maps. (Received August 03, 2008)

1046-37-245 **Omri Sarig***, Mathematics Department, McAllister Building, The Pennsylvania State University, University Park, State College, PA 16802, and **B Schapira**, LAMFA UMR 6140, Faculté de Mathématique et Informatique, Univ. Picardie Jules Verne, 33 Rue St Leu, 80000 Amiens, France. *The generic points for the horocycle flow on $\mathbb{Z}^d$ covers.*

The horocycle flow on a $\mathbb{Z}^d$ cover of a compact hyperbolic surface has no finite invariant measures, and infinitely many (ergodic) infinite invariant Radon measures. We describe the generic points for these measures. Here "generic" means the convergence to the right limit of the ratio of Birkhoff integrals for any pair of continuous functions with compact support whose integral is non-zero.

This is joint work with B. Schapira. (Received August 22, 2008)

1046-37-254 **Jayadev Siddhanta Athreya*** (jathreya@gmail.com), Department of Mathematics, Yale University, Dunham Laboratory, 10 Hillhouse Avenue, New Haven, CT 06511, and **Grigory Margulis**. *Logarithm laws for horocycles and diophantine approximation.*

We discuss some recent results on the excursions of horocycle flow on the modular surface into cusps and the relationship to diophantine approximation. (Received August 23, 2008)

1046-37-280 **Jeanette Olli*** (jolli@email.unc.edu), Campus Box 3250, Chapel Hill, NC 27599. *Endomorphisms of Various Substitution Systems.* Preliminary report.

Given a system (X, T) where X is a Hausdorff space and T acts on X, one question to ask is what are the endomorphisms. The endomorphisms of Sturmian and Toeplitz systems are all powers of the shift σ. Generalizing the Sturmian systems to ones based on two values, α and β, there are cases which do have additional endomorphisms. I also look at properties of a substitution that is a generalization of Conway's pinwheel tiling. (Received August 25, 2008)

1046-37-314 **Emily G. Burkhead***, 3800 Hillsborough Street, Raleigh, NC 27607, and **Jane M. Hawkins** and **Donna K. Molinek**. *A Dynamical Study of a Cellular Automata Model of the Spread of HIV in a Lymph Node.*

We conduct a mathematical study of a cellular automata model of the spread of the HIV virus in a lymph node. The model was proposed by Zorzenon dos Santos and Coutinho and captures the unique time scale of the viral spread. We give some rigorous mathematical results about the time scales and other dynamical aspects of the model as well as discuss parameter and model changes and their consequences. (Received August 25, 2008)

1046-37-324 **Robert L. Devaney*** (bob@bu.edu), Department of Mathematics, Boston University, 111 Cummington St., Boston, MA 02215. *Dynamic Classification of Escape Time Sierpinski Curve Julia Sets.*

For the family of rational maps $z^n + \lambda/z^n$, if all the critical orbits eventually escape to infinity, the Julia set is known to be a Sierpinski curve. There are infinitely many open sets in the λ-plane for which this occurs. Hence all the parameters in these open sets contain homeomorphic Julia sets. However, the dynamics on these sets are usually quite different. We give a complete classification of these dynamical behaviors. Joint work with Kevin Pilgrim. (Received August 26, 2008)

1046-37-428 **Robert W O'Connell*** (rwoconne@indiana.edu), Rawles Hall, 831 East 3rd St, Bloomington, IN 47405. *Pinching Deformations of Rational Maps.*

Let f be a rational map defined on the Riemann sphere. Then f defines a dynamical system whose chaotic locus is called the Julia set. A pinching deformation, $f_t, t > 0$, is a one-parameter family of deformations of f. It is a way to create a parabolic cycle by forcing an attracting cycle and a repelling cycle to collide. The main result shows that for certain pinching deformations, if $f_t \to g$ uniformly, then the Julia set of f_t converges in the Hausdorff topology to the Julia set of g. (Received September 02, 2008)

1046-37-454 **Su Gao*** (sgao@unt.edu), Department of Mathematics, University of North Texas, 1155 Union Circle #311430, Denton, TX 76203, and **Steve Jackson** and **Brandon Seward**. *A coloring property for countable groups.*

For any countable G a G-subflow is a closed invariant subspace of 2^G. A G-subflow is free if it is contained entirely in the free part of 2^G. The main theorem of this talk is that there exists a free G-subflow for any countable group G. Beyond this I will also talk about how to obtain perfectly many disjoint minimal free subflows and how this result is connected with the Borel marker theory developed for hyperfiniteness proofs. (Received September 03, 2008)

1046-37-460 **Paul Leonard Salceanu*** (salceanu@mathpost.asu.edu), Department of Mathematics, Arizona State University, P.O. Box 871804, Tempe, AZ 85287-1804, and **Hal L. Smith**, Department of Mathematics, Arizona State University, P.O. Box 871804, Tempe, AZ 85287-1804. *Liapunov Exponents and Persistence in some Discrete Dynamical Systems.* Preliminary report.

The theory of Liapunov exponents and methods from ergodic theory have been employed by several authors in order to study persistence properties of dynamical systems generated by ODEs or by maps. Here we derive sufficient conditions for uniform persistence, formulated in the language of Liapunov exponents, for a large class of dissipative discrete-time dynamical systems on the positive orthant of $\mathbb{R}^n$, having the property that a nontrivial compact invariant set exists on a bounding hyperplane. We require that all so-called normal Liapunov exponents be positive on such invariant sets. The results ensure the existence of a compact attractor in the interior of the orthant which attracts points of the interior. We apply the results to a plant-herbivore model, showing that both plant and herbivore persist, and to a model of a fungal disease in a stage-structured host, showing that the host persists and the disease is endemic. (Received September 03, 2008)

1046-37-526 **Anna K Savvopoulou*** (as7202@albany.edu), 10 Queens Dr. , Apt 404, Schenectady, NY 12304, and **Karin Reinhold**. *Almost everywhere convergence of a case of weighted averages.* Preliminary report.

Given a probability measure μ on $\mathbb{Z}$, Calderón and Bellow proved a weak type inequality for the maximal operator of $\mu_n\left(f(x)\right) = \sum_{k\in\mathbb{Z}} \mu^n(k) f(\sigma^k(x))$ where μ^n denotes the convolution product.This talk will focus on the case of a sequence of probability measures on $\mathbb{Z}$,denoted by $\{\mu_n\}$, obtained inductively in the following way, $\mu_1 = \nu_1$, $\mu_2 = \nu_1 * \nu_2$, ..., $\mu_n = \nu_1 * \nu_2 * \cdots * \nu_n$, where each one of the ν_i is in turn a strictly aperiodic probability measure on $\mathbb{Z}$ with expectation 0 and finite second moment. We will discuss the almost everywhere convergence of the operators $\mu_n f(x) = \sum_{k\in\mathbb{Z}} \mu_n(k) f(\sigma^k x)$ for $f \in L^1(X)$ and $x \in X$. Throughout the talk σ will stand for a measure preserving transformation of a probability measure space X. (Received September 09, 2008)

1046-37-582 **Mohammad Javaheri*** (mohammad.javaheri@trincoll.edu), 300 Summit St, Department of Mathematics, Trinity College, Hartford, CT 06106. *On a property of plane curves.* Preliminary report.

Let $\gamma : [0,1] \to [0,1]^2$ be a continuous curve such that $\gamma(0) = (0,0)$, $\gamma(1) = (1,1)$, and $\gamma(t) \in (0,1)^2$ for all $t \in (0,1)$. We prove that, for each $n \in \mathbb{N}$, there exists a sequence of points A_i, $0 \le i \le n+1$, on γ such that $A_0 = (0,0)$, $A_{n+1} = (1,1)$, and the sequences $\pi_1(\overrightarrow{A_iA_{i+1}})$ and $\pi_2(\overrightarrow{A_iA_{i+1}})$, $0 \le i \le n$, are positive and the same up to order, where π_1, π_2 are projections on the axes. Generalizations to higher dimensions and connections to discrete dynamical systems are also given. (Received September 08, 2008)

1046-37-612 **Eric Forgoston***, Naval Research Laboratory, Code 6792, 4555 Overlook Avenue, SW, Washington, DC 20375-5337, and **Lora Billings** and **Ira B. Schwartz**. *Stochastic Epidemic Model Reduction: A Normal Form Approach.* Preliminary report.

We consider a stochastic Susceptible-Exposed-Infected-Recovered (SEIR) epidemiological model. Through the use of a normal form coordinate transform, we are able to analytically derive the stochastic center manifold along with the associated, reduced set of stochastic evolution equations. The transformation correctly projects both the dynamics and the noise onto the center manifold. Therefore, the solution of this reduced stochastic dynamical system yields excellent agreement, both in amplitude and phase, with the solution of the original stochastic system for a temporal scale that is orders of magnitude longer than the typical relaxation time. These continuous solutions are found using Langevin equations having Gaussian noise that describe the fluctuations of the SEIR dynamics about an equilibrium. To examine the effects of general noise, the continuous results are compared with those found using a Markov simulation having finite population size in which the noise is due to internal fluctuations. (Received September 09, 2008)

1046-37-631 **Elizabeth D Russell*** (erussell@math.bu.edu), Department of Math at Boston University, 111 Cummington St, Boston, MA 02215. *The Complex Dynamics of Singularly Perturbed Rational Maps.*

We study the dynamics of a family of complex rational maps. We will be especially concerned with the topological structure of the Julia set that arises from iterating such a map. (Received September 09, 2008)

1046-37-632 **Elizabeth D Russell*** (erussell@math.bu.edu), Department of Math at Boston University, 111 Cummington St, Boston, MA 02215. *A Generalized Version of the McMullen Domain.*

We study the dynamics of a family of complex rational maps, generalizing a result by McMullen. We will be especially concerned with the topological structure of the Julia set of such a map. (Received September 09, 2008)

1046-37-635 **Sebastian M Marotta*** (smarotta@pacific.edu), Department of Mathematics, University of the Pacific, 3601 Pacific Avenue, Stockton, CA 95211. *Singular Perturbations of Complex Polynomials.*

We study the dynamics of families of complex maps that are singular perturbations of polynomials. We focus on the topological characteristics of the Julia and Fatou sets that arise. (Received September 09, 2008)

1046-37-637 **Mark Braverman***, Microsoft Research, One Memorial Drive, Cambridge, MA 02142. *Computability and Complexity of Julia sets.*

In this talk we will survey recent progress on the computability and complexity problems surrounding Julia sets. (Received September 09, 2008)

1046-37-656 **Michael Hochman*** (hochman@math.princeton.edu), Department of mathematics, Fine Hall, Washington rd., Princeton, NJ 08544. *$\mathbb{Z}^d$-actions on the Cantor set: Approximation, Rohlin properties and recursion theory.*

I will discuss recent work about the space A of continuous actions of $\mathbb{Z}^d$ on the Cantor set, $d > 1$, specifically questions of density and genericity of dynamical properties. The topology of A is controlled to some extent by shifts of finite type, and recent constructions and invariants for SFTs can be appied to these proplems. In particular, I will discuss the existence of actions with dense isomorphism class (the weak Rohlin property) and why actions cannot be effectively described; why, in contrast to the situation in the space of $\mathbb{Z}$-actions, there does not exist a co-meagre isomorphism class (the strong Rohlin property fails); and other results concerning the approximation of certain types of actions by effective ones. (Received September 09, 2008)

1046-37-704 **David Constantine*** (constand@umich.edu), Department of Mathematics, 2074 East Hall, 530 Church St, Ann Arbor, MI 48109. *On Compact Clifford-Klein Forms of $SL_{n-2}(\mathbb{R})\backslash SL_n(\mathbb{R})$.* Preliminary report.

The problem of compact Clifford-Klein forms is to determine all pairs of Lie groups (H, J), where J is a closed subgroup of H, which have a compact quotient $J\backslash H/\Gamma$ by a discrete subgroup of H that acts properly discontinuously on $J\backslash H$. When J is noncompact many cases of this problem are open. The basic case of $SL_{n-k}(\mathbb{R})\backslash SL_n(\mathbb{R})$ is not completely solved; the main results are due to Zimmer and collaborators for $k \geq 3$ and to Benoist for $k = 1$ and n odd, both showing that compact forms do not exist. In this talk I will present the following result for $k = 2$. Any compact form is given by the following construction: there is a subgroup L of $SL_n(\mathbb{R})$ containing a cocompact lattice Λ such that $SL_{n-2}(\mathbb{R})\backslash SL_n(\mathbb{R})/\Gamma$ is naturally identified with $(L \cap SL_{n-2}(\mathbb{R}))\backslash L/\Lambda$. This confirms a remark by Margulis that all known constructions of compact forms for reductive J are based on the existence of such a subgroup and reduces the compact form question to the algebraic question of whether such a subgroup L exists. This is a preliminary report on ongoing research. (Received September 10, 2008)

1046-37-705 **Daniel J. Rudolph*** (rudolphd@math.colostate.edu), Dept. of Mathematics, Colorado State University, 1874 Campus Delivery, Fort Collins, CO 80523. *Using orbit equivalence as a model for ergodic systems.*

There are two classical model spaces for measure preserving dynamical systems, the Lebesgue measure preserving maps of the unit interval in the strong operator topology and the shift invariant Borel probability measures on $[0, 1]^{\mathbb{Z}}$. I will describe a third, the measure preserving maps orbit equivalent to some fixed aperiodic and ergodic transformation endowed with the Halmos metric. Generic behavior is the same in all three models. I will discuss the problem of extending work with Matt Foreman and Benjy Weiss on the complexity of the isomorphism relation in ergodic theory to this model. (Received September 10, 2008)

1046-37-711 **Basilio Messano*** (messano@unina.it), University of Napoli, Department of Mathematics, Napoli, Italy. *Globally Stable Equilibria.*

The first part of this talk deals with dynamical systems governed by a function

$$F\colon [0,1]\times[0,1]=Q\to Q$$

under the hypothesis that $F(x,y)=(f(x,y),x)$ with $f\colon Q\to[0,1]$ continuous and increasing with respect to y. It is shown that if the set Fix$F$ of fixed points of F is totally disconnected and F does not have any periodic orbits of period 2, then for all $(x,y)\in Q$ the sequence $\{F^n(x,y),\ n=0,1,\dots\}$ converges to a point of Fix$F$.

The second part of the talk deals with dynamical systems of the form (triangular)

$$F(\mathbf{x})=(f_1(x_1),f_2(x_1,x_2),\dots,f_q(x_1,\dots,x_q))+\mathbf{x}_I$$

where $\mathbf{x}_I\in\mathbf{R}^q$, and the functions $f_i,\ i=1,\dots,q$ are uniformly continuous. We assume that F has one and only one fixed point $\mathbf{x}_s$. Conditions are given that imply the global stability of the dynamical system governed by F, i.e. the convergence to $\mathbf{x}_s$ of all sequences of iterates of the function F regardless of their initial state. (Received September 10, 2008)

1046-37-764 **Tom Meyerovitch*** (tomm@post.tau.ac.il), School of Mathematical Sciences, Tel-Aviv University, Ramat-Aviv, 69978 Tel Aviv, Israel. *Recursive and algorithmic aspects of growth complexity for multidimensional SFTs.*

For 1-dimensional SFTs, the topological entropy is in a certain sense the unique non-trivial scale at which asymptotic growth complexity can be measured. However, a multidimensional SFT can have a variety of asymptotic growth rates. In particular, it has been noted over 15 years ago by Tsirelson that growth complexities of the form $\exp(n^{\alpha})$ are possible for non-integer α's. Using the terminology of Ferenczi-Park, such subshifts have entropy dimension α.

In this talk, I will give recursive-theoretic interpretations to some scales of growth rates for SFTs. For example, the possible entropy dimensions for $\mathbb{Z}^d$-SFTs are precisely numbers $x\in[0,d]$ of the form $x=\lim_{n\to\infty}\inf_{k\geq 1}f(n,k)$, where $f:\mathbb{N}\times\mathbb{N}\to\mathbb{R}$ is a recursive function. (Received September 11, 2008)

1046-37-770 **Yves Benoist*** (benoist@math.u-psud.fr), Universite Paris-Sud, Mathematics, Bat 425, 91405 Orsay, France, and **Jean-Francois Quint** (quint@math.univ-paris13.fr), Universite Paris-Nord, 93430 Villetaneuse, France. *Invariant subsets and stationary probabilities on homogeneous spaces.*

Let G be a simple Lie group, X be a G-homogeneous space of finite volume, and H be a Zariski dense subgroup of G. We show that, the Haar probability on X is the only atom-free H-invariant probability on X. Moreover every H-invariant subset of X is either finite or dense. The proof of these facts implies also the stiffness property for stationary measures on X, uses random walks on X, and applies to other homogeneous spaces of finite volume. (Received September 11, 2008)

1046-37-785 **R. Daniel Mauldin*** (mauldin@unt.edu), Mathematics Department, University of North Texas, Box 311430, Denton, TX 76203, and **Alexander P. McLinden**. *Random Closed Sets Viewed As Random Recursions.*

It is known that the box dimension of a Martin-Lof random closed set in $\{0,1\}^N$ is $d=\log_2(\frac{4}{3})$. We show how the developed theory of random recursive constructions may be applied to obtain the fact that the d-dimensional Hausdorff measure of such a set is 0 and find the exact Hausdorff dimension function: A Martin-Lof random set has positive and finite measure with respect to the Hausdorff measure, H^g, where $g(t)=t^d(|log|log(t)||)^{d-\frac{\log 4}{\log 3}}$. We show how this theory may be applied to general random closed sets including those where dying is allowing. (Received September 11, 2008)

1046-37-788 **Gheorghe Craciun*** (craciun@math.wisc.edu), Department of Mathematics, University of Wisconsin-Madison, Madison, WI 53706. *Graph-theoretic criteria for injectivity and unique equilibria in biochemical reaction networks.*

Biochemical reaction network models give rise to dynamical systems that are usually high dimensional, nonlinear, and have many unknown parameters. Due to the presence of these unknown parameters (such as reaction rate constants) direct numerical simulation of the chemical dynamics is practically impossible. On the other hand, we will show that important properties of these systems are determined only by the network structure, and do not depend on the unknown parameters. For example, some reaction networks may give rise to multiple positive equilibria (i.e., they may function as a "biochemical switch") while others cannot exhibit multiple equilibria for any values of the reaction rate parameters. We will point out connections between the capacity of a reaction network to become a biochemical switch, and properties of signed graphs and digraphs that encode the combinatorics of matrix sign patterns of the associated dynamical system. This is joint work with Murad Banaji. (Received September 11, 2008)

1046-37-792 **David M Fisher**, **Boris V Kalinin** (kalinin@jaguar1.usouthal.edu) and **Ralf J Spatzier*** (spatzier@umich.edu). *Higher rank Anosov actions on tori.*

We study actions of Z^k, $k > 1$ on tori T^n with at least one Anosov element. Under suitable conditions these actions are smoothly conjugate to the induced action on homology, e.g. when the action is "totally non-symplectic". (Received September 11, 2008)

1046-37-927 **James A Yorke*** (yorke@umd.edu), Math Dept, Univ. of Maryland, College Park, MD 20742. *Why Period-Doubling Cascades Occur.* Preliminary report.

In numerical investigations, it is common to see "period doubling cascades". In a "cascade", as a map parameter is varied a periodic orbit is seen to undergo an infinite sequence of period doublings. When a cascade exists, Feigenbaum's famous results describe the scaling we should expect to see. But it ignores the question of why these cascades exist. That is the question I address. I will present a number of examples where cascades can be proven to exist. Some of our examples are one dimensional and others are high dimensional strongly coupled families of 1D maps. This is work with Evelyn Sander. (Received September 12, 2008)

1046-37-945 **Michel L. Lapidus** (lapidus@math.ucr.edu), 900 University Ave., Math Dept., Riverside, CA 92507, and **Robert G. Niemeyer*** (niemeyer@math.ucr.edu), 900 University Ave., Math Dept., Riverside, CA 92507. *Towards a Classification of Periodic Orbits of Particular Fractal Billiards.*

We have proven that there exists a nontrivial periodic orbit of the Koch snowflake billiard. We provide the construction of this periodic orbit (via a collection of IFS's) and examine periodic orbits of other pre-fractal billiard tables. We provide experimental evidence suggesting the existence of periodic orbits of the standard and fat Sierpinski carpet (the analogue of a fat Cantor set in the plane) and other snowflake billiards, as well as an IFS-based method for approaching a rigorous proof of the existence of periodic orbits of these particular billiard tables. Moreover, a brief discussion of fractal tilings of the plane and their implications for fractal billiards is given. (Received September 12, 2008)

1046-37-953 **Domenico Aiello**, **Hansheng Diao**, **Zhou Fan**, **Daniel O. King** and **Jessica Lin*** (jessicalin@nyu.edu), Courant Institute of Mathematical Sciences, 251 Mercer Street, New York, NY 10012, and **Cesar E. Silva**. *Measurable Time-Restricted Sensitivity.* Preliminary report.

Sensitive dependence on initial conditions, typically a topological notion, is one of the most common characterizations of a chaotic dynamical system. In 2006, the SMALL Ergodic Theory Group at Williams College introduced measurable sensitivity, a measure-theoretic notion of sensitive dependence on initial conditions. We study a stronger notion of measurable time-restricted sensitivity, which is closely related to the measure-theoretic entropy of a dynamical system. This talk is based on work done by the 2008 SMALL Ergodic Theory group. (Received September 12, 2008)

1046-37-1001 **James T Long***, 809 Montbard Drive, West Chester, PA 19382, and **Chu Yue (Stella) Dong**, **Corey Staten**, **Rytis Umbrasas** and **Clifford A Reiter**. *A Cellular Model for Spatial Population Dynamics.*

Interacting populations exhibit complex behavior in nature. Classic quadratic iteration models with two or three populations exhibit some of the features seen in nature, but fail to account for spatial variation. Indeed, the diversity paradox is that many classic population models predict one species dominates while nature exhibits diversity. While various schemes have been presented to address this dilemma, we present a simple, deterministic cellular model that incorporates classic iteration schemes and a spatial migration component that provides for self-organizing and rich behavior. Our visualization method allows us to observe dynamically changing predominance of species, global diversity, waves of species progression, and highly organized spiral structures. (Received September 13, 2008)

1046-37-1094 **Andy Q. Yingst***, PO Box 889, Lancaster, SC 29721, and **R. Daniel Mauldin**. *An Approach at the Binomial Transformation Problem.* Preliminary report.

The binomial transformation (also known as the Pascal adic transformation) is a map defined on all but countably many points of $\{0,1\}^N$; by $T : 0^i1^j10x \mapsto 1^j0^i01x$. It is known that the ergodic measures for T are precisely the Bernoulli trial measures, but it is unknown and has been of some interest in recent years whether T is weak-mixing for any of these measures.

We show that this question is equivalent to the existence of a bounded solution to a discrete recurrence relation, and we discuss methods of attack at this problem. (Received September 14, 2008)

1046-37-1099 **Fang Wang*** (wangfang@math.northwestern.edu), Department of Mathematics, Northwestern University, 2033 Sheridan Road, Evanston, IL 60201. *Minimal Measures for Lagrangian Systems on 2-Manifold.* Preliminary report.

We present our results on action-minimizing measures for geodesic flows on compact surfaces with genus $g > 1$. We show that for each rational rotation vector h, there is an action-minimizing measure associated to h, which is supported on a finite set of closed orbits. Our work extend Bangert's results on minimal geodesics on torus to higher-genus surfaces. (Received September 14, 2008)

1046-37-1132 **Sasa Kocic*** (s.kocic@utoronto.ca), Department of Mathematics, University of Toronto, Toronto, Ontario M5S 2E4, Canada. *Reducibility of skew-product systems with Brjuno base flows.*

Recently, renormalization methods have been developed that are well-suited for dealing with problems in dynamics involving small divisors. By a scaling of the phase space, one transforms them into large divisors that can be eliminated by a coordinate change. In this paper, we construct a renormalization scheme that applies to the problem of the local reducibility of analytic skew-product flows on $\mathbb{T}^d \times \mathrm{SL}(2,\mathbb{R})$. A similar renormalization scheme has been applied to the problem of the existence of quasi-periodic motion (invariant tori) in families of near-integrable vector fields. In the case of skew-product flows, we show that there is a codimension three stable manifold of vector fields that approach an integrable limit set under renormalization, and that all vector fields on the stable manifold are reducible. We apply the method to prove a reducibility theorem for families of skew-product flows with Brjuno base frequency vectors. Earlier results for skew-product flows, such as the pioneering work by Dinaburg and Sinai, primarily focus on particular families and Diophantine frequencies. (Received September 14, 2008)

1046-37-1141 **Oumarou Njoya*** (njoyaoum@msu.edu), 444 Division St, East Lansing, MI 48823, and **Zach Flres**. *The Dynamics of Nonlinear Tent-like Maps.*

Consider the general tent-like map given by:

$$F(x) = \begin{cases} cx^b & 0 \leq x < .5 \\ a - ax^b & .5 \leq x < 1 \end{cases} \quad \textit{where } a, b, c \textit{ are real}$$

In this talk we explore the dynamics of F under iterations. Specifically we give sufficient and necessary conditions for the existence of fixed points and classify them in terms of their behavior (attracting or repelling). Furthermore we provide graphical (bifurcation diagrams and density graphs) and numerical (Lyapunov exponents) evidence for chaotic behavior. Periodic points of period-2 are also classified. (Received September 14, 2008)

1046-37-1256 **John E. Franke*** (franke@math.ncsu.edu), Department of Mathematics, Box 8205, North Carolina State University, Raleigh, NC 27695, and **Abdul-Aziz Yakubu**. *S-I-S Epidemic Models with Disease Induced Mortality in Periodic Environments.* Preliminary report.

In constant environments the disease dynamics of simple discrete-time epidemic models without disease induced mortality are driven by the demographic dynamics. In periodic environments we show that the demographic dynamics do not always drive the disease dynamics. The introduction of the disease induced mortality gives a model where the disease-free dynamics do not drive the disease dynamics. An S-I-S model is developed to study the combined effects of disease induced mortality and periodic environments. (Received September 15, 2008)

1046-37-1285 **Ionut Chifan*** (ichifan@math.ucla.edu), 1243 Federal Ave, Apt #108, Los Angeles, CA 90025, and **Adrian Ioana** (aioana@caltech.edu), Los Angeles, CA. *Ergodic subequivalence relations induced by a Bernoulli action.*

In this talk we will discuss the *deformation/ spectral gap* rigidity principle in von Neumann algebras which was originally introduced by S. Popa, and we derive some applications to ergodic theory. For example, we prove the following result: Let Γ be a countable group and denote by $\mathcal{S}$ the equivalence relation induced by a Bernoulli action $\Gamma \curvearrowright [0,1]^\Gamma$ where $[0,1]^\Gamma$ is endowed with the product Lebesque measure. Then for any subequivalence relation $\mathcal{R}$ of $\mathcal{S}$ there exists a partition $\{\mathcal{X}_i\}_{i\geq 0}$ of $[0,1]^\Gamma$ with $\mathcal{R}$-invariant measurable sets such that $\mathcal{R}|_{\mathcal{X}_0}$ is hyperfinite and $\mathcal{R}|_{\mathcal{X}_i}$ is strongly ergodic for every $i \geq 1$. (Received September 15, 2008)

1046-37-1316 **Jason E Snyder*** (jes0082@unt.edu), 1155 Union Circle, #311430, CO: Jason Snyder, Denton, TX 76203-5017, and **Mariusz Urbanski**. *On the Road to a Classification of Attractors of injective Iterated Function Systems in* $\mathbb{R}^1$.

It will be shown that an attrtractor of an injective Iterated Function System on $mathbbR^1$ must be perfect. It will also be shown that if the cardinality of the collection of degenerate connected compenents is greater than 0 and finite, then it is homeomorphic to an attractor of an injective IFS. (Received September 15, 2008)

1046-37-1322 **Keith E Howard*** (howard_ke@mercer.edu), Mercer University, 1400 Coleman Ave, Department of Mathematics, Macon, GA 31210. *Being Applied in a Pure World.*

Few would deny the friendly rivalry that exists between "pure" and "applied" mathematicians. Lack of mutual appreciation, and limited resources can lead to great challenges, but also great opportunities. As an applied mathematician, I received my educational training in "pure" math programs. In my professional career, I have served as one of the few, if not only, applied mathematicians in "pure" math programs. In this talk, I will highlight challenges this circumstance presents to collegial and faculty-student relationships. I will also highlight opportunities that this scenario can present. (Received September 15, 2008)

1046-37-1326 **Reinhard C Laubenbacher*** (reinhard@vbi.vt.edu), Washington St., Blacksburg, VA 24061, and **Abdul S Jarrah** and **Alan Veliz-Cuba**. *Dynamical systems over graphs: the relationship between graph topology and dynamics.*

Time-discrete dynamical systems with a finite state space appear many applications in engineering and biology. In many cases, an important structural feature of these systems is that the variable dependencies can be expressed by a directed graph. The topology of this graph plays an important role in the determining the dynamics of the system. This talk will present some results about this relationship. (Received September 15, 2008)

1046-37-1361 **David Richeson** and **Jim Wiseman*** (jwiseman@agnesscott.edu), Agnes Scott College, 141 E. College Ave., Decatur, GA 30030. *Symbolic dynamics for topological hyperbolic maps.*

We use Conley index theory and cocylic subshifts to detect interesting symbolic dynamics in topologically hyperbolic systems. The methods also apply to expansive systems, with the Conley index serving as a substitute for the shadowing property, and can be generalized to numerical approximations. (Received September 15, 2008)

1046-37-1389 **Daniel M. Look*** (daniel.m.look@williams.edu), Department of Mathematics and Statistics, Williams College, Williamstown, MA 01267. *Imaginary Circle Inversions and Sierpinski Carpets.* Preliminary report.

We will begin by introducing multiple circle inversion, followed by an investigation into what it means for a circle to have complex radius in this situation. Finally, we will explore the dynamics and Julia sets of a two-parameter family of rational maps formed from multiple circle inversion where the circles have complex radii. (Received September 15, 2008)

1046-37-1419 **Robert J Sacker*** (rsacker@usc.edu), Mathematics Dept., University of Southern California, 3620 S. Vermont Ave., KAP 108, Los Angeles, CA 90089-2532. *Semigroups of Maps and Periodic Difference Equations.*

A collection $\mathcal{M}$ of monotonic maps from the positive reals to the positive reals is defined. Each map is linearly bounded, has non-negative Schwarzian and is either concave increasing or convex decreasing. It is shown that $\mathcal{M}$ is a semigroup under composition that contains the sub-semigroup of fractional linear maps and each function in $\mathcal{M}$ that is uni-linearly bounded has a globally attracting exponentially asymptotically stable fixed point. Thus we obtain a condition under which a periodic difference equation (mapping system) will have a periodic solution having the same properties. Certain restricted algebraic operations are valid in $\mathcal{M}$ and the structure of $\mathcal{M}$ is explored together with conjectures regarding the interlacing of roots of a rational function in $\mathcal{M}$. (Received September 15, 2008)

1046-37-1544 **Francois Ledrappier** (fledrapp@nd.edu), 255 Hurley Hall, Notre Dame, IN 46556, and **Seonhee Lim*** (slim@math.cornell.edu), 593 Malott Hall, Cornell University, Ithaca, NY 14853-4201. *Volume entropy and measure of maximal entropy of hyperbolic buildings.* Preliminary report.

In contrast to symmetric spaces, we show that for certain hyperbolic buildings with symmetric metric on each apartment, the Liouville measure is not equal to the Bowen-Margulis measure i.e. the measure of maximal measure-theoretic entropy. As a consequence, we obtain a strict lower bound on the volume entropy for such buildings in terms of "weighted" perimeter. (Received September 16, 2008)

1046-37-1568 **Jarkko Kari*** (jkari@utu.fi), Department of Mathematics, FI-20014 University of Turku, Finland. *Mortality and periodicity of dynamical systems.*

Let (X,F) be a topological dynamical system and let H be a fixed open subset of X, called the halting set. We call (X,F) mortal with respect to H if all orbits visit set H. The mortality problem is the algorithmic question to determine if a given system is mortal w.r.t a given halting set H.

The mortality problem is known to be undecidable for many families of dynamical systems. In particular, in 1966 P.K.Hooper proved it undecidable for Turing machines. For cellular automata, the problem is seen undecidable using the nilpotency problem. Recently we have shown the undecidability of the mortality problem for families of bijective systems: for reversible cellular automata (K, Lukkarila 2007), and for reversible Turing machines and reversible counter machines (K, Ollinger 2008).

The periodicity problem refers to the algorithmic question to decide if all orbits of a given dynamical system are periodic. The periodicity problem is undecidable among cellular automata, Turing machines and counter machines - all these results can be proved using the undecidability of the mortality problem (K, Ollinger 2008).

Finally, we demonstrate how the mortality problem of piecewise affine maps of the plane can be reduced to the domino problem, thus giving a new proof for its undecidability. (Received September 16, 2008)

1046-37-1594 **Champike Attanayake*** (attanac@muohio.edu), Miami University Middletown, Middletown, OH 45042. *Long Time Error Estimate Using Contraction Properties of the Huxley's Equation.*

In this paper, long time error estimates are obtained using non-traditional methods for the Huxley's equation

$$u_t - u_{xx} = u(1-u)(u-a) \quad \text{for} \quad 0 < a < 1/2,$$

Traditional methods for analyzing exact error propagation depends on the stability of the numerical method employed. Whereas, in this paper the analysis of the exact error propagation uses evolving attractors and only depends on the stability of the dynamical system. The use of the smoothing indicator yields *a posteriori* estimates on the numerical error instead of *a priori* estimates. (Received September 16, 2008)

1046-37-1651 **Alfonso Vignoli*** (vignoli@mat.uniroma2.it). *An extension of the notion of zero-epi maps to the context of topological spaces.*

We introduce the class of hyper-solvable equations whose concept may be regarded as an extension to the context of topological spaces of the known notion of 0-epi maps. After collecting some notation, definitions and preliminary results we give a homotopy principle for hyper-solvable equations. We provide examples showing how these equations arise in the framework of Leray-Schauder degree, Lefschetz number theory and essential compact vector fields in the sense of A. Granas. (Received September 16, 2008)

1046-37-1664 **Nicholas E Long*** (longne@sfasu.edu), Stephen F. Austin State University, Department of Mathematics and Statistics, P.O. Box 13040, SFA Station, Nacogdoches, TX 75962-3040. *Fixed Point Shifts of Inert Involutions.*

Given a mixing shift of finite type X, we consider what subshifts of finite type $Y \subset X$ can be realized as the fixed point shift of an inert involution of X. We establish a condition on the periodic points of X and Y that is necessary for Y to be the fixed point shift of an inert involution of X. If the zeta function of X is 1 mod 2, we show that this condition is sufficient to realize Y as the fixed point shift of an involution, up to shift equivalence on X. Given an inert involution f on a mixing shift of finite type X, we characterize what f-invariant subshifts can be realized as the fixed point shift of an inert involution. (Received September 16, 2008)

1046-37-1665 **Christopher F. Novak*** (cfnovak@umd.umich.edu), Department of Mathematics and Statistics, College of Arts, Sciences, and Letters, 4901 Evergreen Road, Dearborn, MI 48128. *Centralizers in the Interval Exchange Group.*

Let $\mathcal{E}$ represent the group of interval exchange transformations. For $f \in \mathcal{E}$, the structure of the centralizer $C_{\mathcal{E}}(f)$ is characterized by the dynamical properties of f. If f is topologically minimal, then either $C_{\mathcal{E}}(f)$ is virtually abelian and contains a torus subgroup, or $C_{\mathcal{E}}(f)$ is virtually cyclic. These situations are distinguished by the growth rate of the discontinuities of f under iteration. If f has finite order, then $C_{\mathcal{E}}(f)$ contains a subgroup isomorphic to $\mathcal{E}$. In general, $C_{\mathcal{E}}(f)$ is characterized by the occurrence of these dynamical situations on maximal invariant subsets of f. This characterization of centralizers is used to prove $\mathrm{Aut}(\mathcal{E}) \cong \mathcal{E} \rtimes \mathbb{Z}/2\mathbb{Z}$. (Received September 16, 2008)

1046-37-1748 **Shari Wiley*** (shari_wiley@yahoo.com), Howard University, Dept. of Mathematics, ASB-B, 213, Washington, DC, and **Abdul-Aziz Yakubu** (ayakubu@howard.edu) and **Michael Fogarty** (mfogarty@mercury.wh.whoi.edu). *Impact of Harvesting in a Discrete-Time Predator-Prey Model.*

An age-structured, discrete-time model is used to study the impact of fishing exploitations in a predator-prey system. This project was motivated by the work of Basson and Fogarty, who used an age-structured model with Ricker-type recruitment functions to account for interspecific interactions and exploitations. In this research, we generalize their model to study recruitment mechanisms that exhibit both compensatory (equilibrium) and overcompensatory (oscillatory) dynamics. We explore the implications of these different dynamics on the long-term survival of the exploited predator and prey species. (Received September 16, 2008)

1046-37-1821 **L. Loizou***, James Madison University, Dept. of Math and Stats, Harrisonburg, VA 22807, and **M. Dankwa**, **J. Herburt-Hewell** and **J. C. Ortega**. *A chaotic day at the beach.* Preliminary report.

The chaotic waterwheel, a physical model of the Lorenz system, is a well studied and fairly well understood problem in dynamical systems. Last summer, NREUP participants at James Madison University designed, developed and constucted a sandwheel, in which sand replaced water. Linear stability analysis was used to explore dynamics of the system. Numerical experiments indicated that the center of mass could be used to classify the system's behavior; including constant, rolling, periodic and chaotic states. Ongoing research compares physical observations to the mathematical observations and finding consistency between the two. This talk outlines our work on the 'not-so-chaotic' sandwheel. (Received September 16, 2008)

1046-37-1886 **Santanu Chakraborty*** (schakraborty@utpa.edu), Assistnat Professor, Mathematics, UTPA, 1201 West University Drive, Edinburg, TX 78541. .

The usual Gauss transformation $U(x) = \frac{1}{x} - [\frac{1}{x}]$ for $x \in (0, 1]$ gives rise to a dynamical system which is nothing but the usual continued fraction expansion $[a_1, a_2, \cdots]$. The invariant measure for this dynamical system is given by $d\mu(x) = \frac{1}{\log 2} \frac{1}{1+x} \, dx$ for $x \in (0, 1]$. Now instead of the usual continued fraction expansion, if we consider the θ-expansion corresponding to some $\theta \in [0, 1)$, then this expansion also corresponds to some dynamical system which is obtained from a generalized version of the Gauss transformation given by $T(x) = \frac{1}{x} - \theta[\frac{1}{\theta x}]$ for $x \in (0, \theta]$. In this talk, we make an elaborate study on the generalized Gauss transformation. (Received September 16, 2008)

1046-37-1937 **Cordelia McGehee***, 77 Mid Oaks Lane, Roseville, MN 55113, and **Christophe Golé**, **Gillian Riggs** and **Samantha Oestreicher**. *Configuration Spaces in Phyllotaxis.* Preliminary report.

Phyllotaxis is the study of plant organ arrangements such as the scales on a pine cone or the florets on a sunflower. A simple model for these arrangements consists of stacking disks on the surface of a cylinder. The resulting configuration is determined by the initial chain of disks around the cylinder. In this talk, we will examine some of the configuration spaces of those chains. (Received September 16, 2008)

1046-37-1983 **Andrew J.N. Parrish*** (aparrish@memphis.edu), 1055 Goodman St., Memphis, TN 38111. *Pointwise Convergence of Ergodic Averages in Orlicz Spaces.*

We construct a sequence $\{a_n\}$ such that for any measure preserving system (X, Σ, m, T) the ergodic averages

$$A_N f(x) = \frac{1}{N} \sum_{n=1}^{N} f(T^{a_n} x)$$

converge a.e. for all f in $L \log\log(L)$, but fail to have a finite limit for some L^1 function. In fact, we show that one may construct sequences for which these averages converge a.e. for any Orlicz space strictly smaller than L^1, but fail to converge for some L^1 function. This ultimately extends the work of K. Reinhold. Reinhold, building on the work of A. Bellow, constructed a sequence for which the averages $A_N f(x)$ converge a.e. for L^p, $p > 1$, but do not converge for some f in L^1. Our method, introduced by Bellow and later extended by Reinhold and M. Wierdl, is perturbation. (Received September 17, 2008)

1046-37-1992 **Zachary Flores*** (floresza@msu.edu), 2795 Lamoreaux LN, Holt, MI 48842, and **Oumarou Njoya**. *On the Dynamics of Non-Linear Tent-Maps.* Preliminary report.

Consider a family of non-linear tent maps defined by $F(x) = cx^b$ if $0 \le x < 1/2$ and $F(x) = a(1 - x^b)$ if $1/2 \le x < 1$. Here a, b, c are real parameters. By finding conditions on $a, b,$ and c, we explore dynamic properties of F that arise under continuous iteration. We present results about the existence and nature of fixed points and cycle points. We will also investigate chaotic behaviors of F using graphical means (such as bifurcation diagrams and density graphs) and numerical studies (using Lyapunov exponents). Connections between the dynamics of F and fractal sets will be discussed. (Received September 16, 2008)

1046-37-2029 **Cecilia I Gonzalez Tokman*** (cecilia@math.umd.edu), Department of Mathematics, Mathematics Building, University of Maryland, College Park, MD 20742-4015, and **Brian R Hunt**, Department of Mathematics, Mathematics Building, University of Maryland, College Park, MD 20742-4015. *Scaling law for a global bifurcation.*

We present an example of a scaling law for a global bifurcation of a chaotic invariant manifold. The result is applicable to deterministic as well as random dynamical systems and to distinct bifurcation scenarios. Generalization to higher dimensions is also valid. (Received September 16, 2008)

1046-37-2080 **Danny Calegari*** (dannyc@its.caltech.edu), c/o Department of Mathematics, California Institute of Technology, Pasadena, CA 91125. *Nonsmoothable locally indicable group actions on the interval.*

The well-known Thurston stability theorem says that a group of C^1 diffeomorphisms of the unit interval is locally indicable. However this statement is not sharp. We use the method of proof to give a new criterion for a group action to not be topologically conjugate to a C^1 action, in terms of the local order structure of orbits. In fact, we can construct faithful actions of free groups on the interval which are not conjugate to C^1 actions.

More refined information should give constructions of actions which are $C^{1+\alpha}$ but not topologically conjugate to $C^{1+\alpha+\epsilon}$ actions, for any fixed $\alpha \in (0,1)$ and any $\epsilon > 0$. (Received September 17, 2008)

1046-37-2102 **S. Lakshmivarahan** (varahan@ou.edu), School of Computer Science, University of Oklahoma, Norman, OK 73019, and **S. Crowell*** (scrowell@ou.edu), Department of Mathematics, University of Oklahoma, Norman, OK 73019. *Detection and Correction of Forecast Bias Due To Parameter and Initial Condition Errors.*

We present a variational framework for detecting biases and errors in model forecast due to unknown errors in initial conditions and model parameters. The model output at a particular time is compared to a state observation, and the difference is explained to first or second order by variations in parameters and initial conditions. Once these explanatory variations are found, the original model can be corrected to yield a forecast error of approximately zero. (Received September 17, 2008)

39 ► Difference and functional equations

1046-39-30 **Johnny Henderson*** (Johnny_Henderson@baylor.edu), Department of Mathematics, Baylor University, Waco, TX 76798-7328, **Sotiris K. Ntouyas** (sntouyas@uoi.gr), Department of Mathematics, University of Ioannina, 451 10 Ioannina, Greece, and **Ioannis K. Purnaras** (ipurnara@cc.uoi.gr), Department of Mathematics, University of Ioannina, 451 10 Ioannina, Greece. *Positive solutions for systems of three-point nonlinear discrete boundary value problems.*

Existence of eigenvalues yielding positive solutions for systems of a second order three-point discrete boundary value problem is established. The results are obtained by the use of a Guo-Krasnoselskii fixed point theorem in cones. (Received June 16, 2008)

1046-39-87 **John W Cain*** (jwcain@vcu.edu), Department of Mathematics, Box 842014, Virginia Commonwealth University, 1001 West Main Street, Richmond, VA 23284-2014. *Local Asymptotic Stability and Difference Equations of Arbitrary Finite Order.*

The Schur-Cohn and/or Jury Criteria are often used to test for local asymptotic stability of equilibria of difference equations. However, these stability tests are typically implemented only if the underlying difference equations are of low order. In this talk, I will illustrate how one may use the Jury Criteria to analyze local asymptotic stability of equilibria of a class of difference equations with arbitrary finite order. Specifically, I will completely characterize the local asymptotic stability of equilibria of a two-parameter, mth order difference equation which arises in the context of modeling cardiac dynamics. My results yield a criterion for the onset of a particular arrhythmia known as reentrant tachycardia. (Received July 22, 2008)

1046-39-153 **H Sedaghat*** (hsedagha@vcu.edu), Department of Mathematics, Virginia Commonwealth University, Box 842014, Richmond, VA 23284-2014. *On reduction of order of difference equations.*

We discuss a procedure that factors a difference equation of order $k > 1$ into two difference equations of lower orders m and $k - m$. The solutions of the k-th order equation can be obtained from the solutions of this system of two equations. We apply this factorization procedure to large classes of difference equations, including a class (separable equations) that contains the linear non-homogeneous equations. For more details see http://arxiv.org/abs/0804.3579 (Received August 07, 2008)

1046-39-171 **Gerasimos E Ladas*** (geladas@mail.uri.edu), University of Rhode Island, Department of Mathematics, 9 Greenhouse Road, 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 the periodic solutions including periodic trichotomies. (Received August 11, 2008)

1046-39-212 **Youssef Naim Raffoul*** (youssef.raffoul@notes.udayton.edu), University of Dayton, Department of Mathematics, 300 College park, Dayton, OH 45469-2316. *Population Models With Asymptotically Constant Or Periodic Solutions.* Preliminary report.

Given an initial function we show by means of fixed point theory that the unique solution of nonlinear difference equations of the form

$$\triangle x(t) = g(x(t)) - g(x(t-L))$$

converges to a pre-determined constant or to a periodic solution. Then, we show the solution is stable and that its limit function serves as a global attractor. (Received August 19, 2008)

1046-39-219 **Sukanya Basu*** (sukanya@math.uri.edu), Department of Mathematics, University of Rhode Island, Kingston, RI 02881-0816, and **Orlando Merino** (merino@math.uri.edu), Department of Mathematics, University of Rhode Island, Kingston, RI 02881-0816. *Global behavior of solutions to $x_{n+1} = \frac{\alpha+\beta\, x_n+\gamma\, x_{n-1}}{A+B\, x_n+C\, x_{n-1}}$ with non-negative parameters when prime period-two solutions exist.*

For nonnegative parameters α, β, γ, A, B, C such that $A+B+C>0$, consider the difference equation

$$x_{n+1} = \frac{\alpha+\beta\, x_n+\gamma\, x_{n-1}}{A+B\, x_n+C\, x_{n-1}}\,, \quad n=0,1,2,\ldots, \quad (x_{-1},x_0)\in R \tag{E}$$

where either $R=[0,\infty)^2\setminus\{(0,0)\}$ if $A=0$, or $R=[0,\infty)^2$ if $A>0$.

We give a complete qualitative description of the global behavior of solutions for all nonlinear difference equations (E) for which prime period-two solutions exist. (Received August 20, 2008)

1046-39-249 **Raegan J Higgins*** (raegan.higgins@ttu.edu), Texas Tech University, Dept of Mathematics & Statistics, Box 41042, Lubbock, TX 79409-1042. *Oscillation Theory of Dynamic Equations on Time Scales.* Preliminary report.

Using the method of upper and lower solutions and related results from oscillation theory, we will establish oscillation results for the the nonlinear second order functional dynamic equation

$$y^{\Delta\Delta}(t) + f(t, y^{\sigma}(t), y(\tau(t))) \quad = \quad 0$$

on a time scale $[0,\infty)_{\mathbb{T}}$ where $\sup\mathbb{T}=\infty$ and

$$\lim_{t\to\infty}\tau(t)=\infty \quad \text{and} \quad \tau(t)\le t\le\sigma(t).$$

These results extend some earlier criteria for the differential equation case. (Received August 22, 2008)

1046-39-571 **V. L. Kocic*** (vkocic@xula.edu), Mathematics Department, Xavier University of Louisiana, 1 Drexel Dr., New Orleans, LA 70125. *Dynamics of certain periodic nonlinear delay difference equations.*

Boundedness, extreme stability, and existence of periodic orbits of certain periodic nonlinear delay difference equations is studied. In addition the question of attenuance of periodic cycles is addressed. (Received September 08, 2008)

1046-39-605 **Candace Marie Kent*** (cmkent@vcu.edu), Virginia Commonwealth University, Department of Mathematics and Applied Math., 1001 W. Main St., P.O. Box 842014, Richmond, VA 23284-2014, and **Hassan Sedaghat**. *A Bimodal System.* Preliminary report.

We investigate the two-dimensional threshold map, or bimodal system,

$$F(x\,,y) = \begin{cases} G(x\,,y)\,, & \text{if } (x\,,y)\in\mathcal{T}\,, \\ H(x\,,y)\,, & \text{if } (x\,,y)\notin\mathcal{N}\,, \end{cases}$$

where $G : \mathbf{R}^2 \to \mathbf{R}^2$ and $H : \mathbf{R}^2 \to \mathbf{R}^2$ are continuous and $\mathcal{T}$ is a region in $[0,\infty)$. We denote the region $[0,\infty)^2 - \mathcal{T}$ by $\mathcal{N}$. The boundary, $\partial\mathcal{T}$, is considered part of $\mathcal{N}$ and is called the *threshold* of the system. We find sufficient conditions on G and H such that there exist orbits under F that begin in the region $\mathcal{T}$ and eventually end up and remain in $\mathcal{N}$; pass between $\mathcal{T}$ and $\mathcal{N}$ infinitely often; or pass a finite number of times between $\mathcal{T}$ and $\mathcal{N}$ but end up in $\mathcal{N}$. (Received September 09, 2008)

1046-39-640 **Edward A Grove*** (grove@math.uri.edu), University of Rhode Island, Department of Mathematics, Kingston, RI 02881. *Analyzing and comparing the boundedness nature of the positive solutions of two autonomous and two non-autonomous rational difference equations.* Preliminary report.

We analyze and compare the boundedness nature of the positive solutions of two autonomous and two non-autonomous rational difference equations. We will begin analyzing the boundedness nature of the autonomous difference equations, then analyze the boundedness nature when we introduce a period 2 coefficients and proceed with analyzing the boundedness nature with the introduction of period 3 coefficients. (Received September 09, 2008)

1046-39-646 **E A Grove**, Kingston, RI 02881, **Y kostrov*** (ekostrov@math.uri.edu), kingston, RI 02881, **G ladas**, kingston, RI 02881, and **S Schlutz**, providence, RI 02918. *On Riccati Difference Equations With Periodic Coefficients.*

We give a detailed analysis of the Riccati difference equation

$$x_{n+1} = \frac{\alpha_n + \beta_n x_n}{A_n + B_n x_n} \qquad , \qquad n = 0, 1, \ldots$$

where the coefficent sequences

$$\{\alpha_n\}_{n=0}^{\infty} \quad , \quad \{\beta_n\}_{n=0}^{\infty} \quad , \quad \{A_n\}_{n=0}^{\infty} \quad , \quad \{B_n\}_{n=0}^{\infty}$$

are periodic sequences of real numbers with (not necessarily prime) period-2, and where the initial condition $x_0 \in \mathbf{R}$. (Received September 09, 2008)

1046-39-668 **J M Cushing*** (cushing@math.arizona.edu), Department of Mathematics, 617 N Santa Rita, University of Arizona, Tucson, AZ 85721. *Two species competition in a periodic environment.* Preliminary report.

I will consider the classical Leslie-Gower (discrete time) model for two competing species when the coefficients fluctuate periodically. I will focus primarily on the case of period 2 and show that the classic Lotka-Volterra trichotomy of asymptotic competitive outcomes holds. I will then compare the predictions of the periodically forced model to those of relevant autonomous versions of the model. For example, I will show that it is possible for the periodically forced model to predict coexistence of the two species even though (1) it has coefficients which periodically oscillate between values that would predict non-coexistence in the autonomous model or (2) it has coefficients whose period averages predict non-coexistence in the autonomous model. Thus, estimates of biological parameters calculated from data taken during one season alone, or calculated from averages taken over all seasons of the year, might each predict non-coexistence while in fact the two species will coexist according to the model with periodic coefficients. (Received September 09, 2008)

1046-39-722 **Guoping Zhang*** (hyzgp73@yahoo.com), Morgan State University, Department of Mathematics, 1700 E Cold Spring Lane, Baltimore, MD 21251, and **Alexander Pankov**, Morgan State University, Department of Mathematics. *Standing Wave of the discrete nonlinear Schroedinger equations with growing potentials.* Preliminary report.

We investigate the existence of nontrivial standing wave solution of the discrete nonlinear Schroedinger equation with the growing potential at infinity. Fist of all, we derive a compact embedding theorem by using functional analysis theory. Then we combine the variational methods such as Nehari manifold and minimax methods and the compact embedding theorem to show the existence of nontrivial standing wave solution. The exponential decay of the standing wave solutions has also been studied. Finally prove the existence of infinitely many standing wave solutions corresponding to an unbounded sequence of critical values. (Received September 10, 2008)

1046-39-805 **Allan C. Peterson***, Math. Department, Universityof Nebraska-Lincoln, Lincoln, NE 685880130, Lincoln, NE 685880130, **Lynn H. Erbe** (lerbe2@math.unl.edu), Lincoln, NE 685880130, and **Baoguo Jia**, Lincoln, NE 685880130. *Oscillation of sublinear Emden–Fowler dynamic equations on time scales.*

We give an oscillation criteria for a second order Emden–Fowler dynamic equation. As a special case we get a very delicate result for a second order Emden–Fowler difference equation. (Received September 11, 2008)

1046-39-928 **Orlando Merino*** (merino@math.uri.edu), Department of Mathematics, University of Rhode Island, Kingston, RI 02881, and **Sukanya Basu** (sukanya@math.uri.edu), Department of Mathematics, University of Rhode Island, Kingston, RI 02881. *Dynamics of the Leslie-Gower Model with Periodic Coefficients.*

We consider the system of difference equations

$$\begin{cases} x_{n+1} = \dfrac{b_{1,n}\,x_n}{1+c_{1,n}\,x_n+d_{1,n}\,y_n} \\ \\ y_{n+1} = \dfrac{b_{2,n}\,y_n}{1+c_{2,n}\,x_n+d_{2,n}\,y_n} \end{cases} \quad n=0,1,2,\ldots, \quad x_0,\,y_0\geq 0 \qquad \text{(PLG)}$$

where $\{b_{1,n}\}$, $\{b_{2,n}\}$, $\{c_{1,n}\}$, $\{c_{2,n}\}$, $\{d_{1,n}\}$, $\{d_{2,n}\}$, are given p-periodic sequences of positive real numbers. We refer to (PLG) as the *Leslie-Gower model with p-periodic coefficients.*

In this talk we discuss the dynamics of (PLG) on the nonnegative (first) quadrant of the plane when the period is $p=2$. Some results for general period $p>1$ are also given. (Received September 12, 2008)

1046-39-975 **Faruk F Abi-Khuzam*** (farukakh@aub.edu.lb), American University of Beirut, PO Box 11-0236, Riad El-Solh 1107 2020, Beirut, Lebanon. *Asymptotic behavior of solutions of a class of non-linear difference equations.* Preliminary report.

A first order linear difference equation can be solved explicitly, and a simple method for obtaining the solution may be given. In most applications, however, the relevant equation is usually non-linear and a closed form of the solution is, in general, impossible to obtain. This makes it necessary to find the asymptotic behavior of the solution. In this note we obtain the asymptotic behavior of the solution for a class of non-linear difference equations. For completeness we also include a derivation of a closed form of the solution of the general first order linear equation.

Theorem 1. If $f(n)\neq -1$ and a_n is a solution of the difference equation

$$a_{n+1}-a_n-f(n)a_n=g(n)$$

then

$$a_{n+1}=a_1\prod_{k=1}^{n}(1+f(k))+\sum_{k=1}^{n}g(k)\prod_{j=k+1}^{n}(1+f(j))$$

where a_1 is arbitrary.

Theorem 2. Let f be a positive non-decreasing function defined on $(0,\infty)$. Let a_n be a solution of

$$a_{n+1}-a_n=\frac{1}{f(a_n)}$$

satisfying $a_1>0$. Put

$$F(x)=1+\int_0^x f(t)dt, x\geq 0.$$

Then

$$a_n \sim F^{-1}(n) \text{ as } n\to\infty.$$

Example 3. If $a_{n+1}-a_n=a_n^{-\alpha}$, where $a_1,\alpha>0$, then $a_n \sim (\alpha+1)^{\frac{1}{\alpha+1}}n^{\frac{1}{\alpha+1}}$ as $n\to\infty$.

Example 4. If $a_{n+1}-a_n=\exp(-a_n)$, then $a_n \sim \ln n$ as $n\to\infty$. (Received September 13, 2008)

1046-39-1360 **Alice A. Ramos*** (alice_alexander@baylor.edu), Baylor University, Dept. of Mathematics, One Bear Place #97328, Waco, TX 76798-7328. *The Dynamic Lyapunov Equation on Time Scales:.* Preliminary report.

This talk focuses on the development and solution of the dynamic Lyapunov equation on an arbitrary time scale. We will briefly consider application of these results to the stability analysis of linear systems defined on time scales. (Received September 15, 2008)

1046-39-1461 **Heidi Berger*** (heidi.berger@simpson.edu), Simpson College, Department of Mathematics, 701 N. C Street, Indianola, IA 50125. *Homoclinic Orbits for a $2n^{th}$ Order Nonlinear Difference Equation.*

We will use the Mountain Pass Theorem and related results from critical point theory to find nontrivial doubly asymptotic solutions to a $2n^{th}$ order nonlinear difference equation that generalizes a Sturm-Liouville problem. It will be assumed that our nonlinear term grows superlinearly both at the origin and at infinity. An example of our results will be given. (Received September 15, 2008)

1046-39-1473 **Billy J Jackson***, 2121 Nevins Hall, 1500 N. Patterson St, Valdosta, GA 31698-0040.
Adaptive Control in the Nabla Setting.

We present an analysis of stability and Lyapunov criteria for nabla dynamic equations on time scales. (Received September 15, 2008)

1046-39-1575 **Senada Kalabusic*** (senadak@yahoo.com), Department of Mathematics, University of Rhode Island, Kingston, RI 02881. *Nonhyperbolic Dynamics for Competitive Systems in the Plane and Global Period-doubling Bifurcations.*

We investigate the global period-doubling bifurcations of solutions of the equation

$$x_{n+1} = f(x_n, x_{n-1}), \quad n = 0, 1, \dots$$

where the function f satisfies certain monotonicity conditions. We also obtain a global asymptotic result for competitive systems of difference equations in the plane in the nonhyperbolic case when the considered system has an infinite number of equilibrium points located along the graph of a nonincreasing function. (Received September 16, 2008)

1046-39-1576 **M. R. S. Kulenovic*** (mkulenovic@mail.uri.edu), Department of Mathematics, University of Rhode Island, Kingston, RI 02881. *Stability of the Gumowski-Mira Equation with Period-Two Coefficient.*

We investigate the stability of solutions of the Gumowski-Mira equation with a period-two coefficient:

$$y_{n+1} = \frac{y_n}{b_n + y_n^2} - y_{n-1}, \quad n = 0, 1, \dots$$

where

$$b_n = \begin{cases} \alpha \geq 0 & \text{for } n = 2k, \\ \beta \geq 0 & \text{for } n = 2k+1, \quad k = 0, 1, \dots \end{cases}$$

and the initial conditions y_{-1}, y_0 are real numbers. We prove that under some conditions the periodic coefficients will cause unboundedness of most of solutions. (Received September 16, 2008)

1046-39-1579 **Ann Brett*** (ambrett@verizon.net), Department of Mathematics, University of Rhode Island, Kingston, RI 02881. *The effect of periodization of parameters in some monotone difference equations.* Preliminary report.

We discuss the effect of periodization of parameter p in difference equations of second order

$$x_{n+1} = f(p, x_n, x_{n-1}), \quad n = 0, 1, \dots,$$

where f satisfies certain monotonicity conditions. We show that, for some monotonicity conditions, this equation can be reduced to either cooperative or to competitive system of autonomous difference equations in plane. The applications to some basic models in population dynamics are presented. (Received September 16, 2008)

1046-39-1593 **Judith C Stull*** (stullj@temple.edu), Rm 441, Ritter Annex, Temple University, 1301 Cecil B. Moore Avenue, Philadelphia, PA 19122. *The use of formative assessment in university level mathematics courses.*

This is an empirical analysis of formative assessment implementation in university differential equations courses where a regression was performed with the student's final course points as the dependent variable. Controlling for differences in ability, being in one of the formative assessment sections added 10.30 points to the final score, the equivalent of a whole grade difference, that is, a "B," instead of a "C". Difference scores, predicted score minus actual score, were calculated for each student. The students were then sorted into those who achieved well above what was expected (80th -100th percentile) and those who achieved well below what was expected (0- 20th percentile). Students in the first group devoted time early in the semester to their course work, while those in the other group spent almost twice as many hours at a paid job at the beginning of the semester and the reallocated their time at the end. (Received September 16, 2008)

1046-39-1601 **Senada Kalabusic*** (senadak@yahoo.com), Department of Mathematics, University of Rhode Island, Kingston, RI 02881, and **Nurkanovic Mehmed** (nurkanm@yahoo.com), University of Tuzla, Tuzla, Bosnia-Herzegovina. *On the Dynamics of* $x_{n+1} = p_n + \frac{x_{n-1}}{x_{n-2}}, \quad n = 0, 1, ...$ *with a Period-2 and Period-3 Coefficient.*

We investigate the periodic nature, the boundedness character, and the global asymptotic stability of solutions of the difference equation

$$x_{n+1} = p_n + \frac{x_{n-1}}{x_{n-2}}, \quad n = 0, 1, 2, ...,$$

where the sequence p_n is periodic with period $k \in \{2, 3\}$ with positive terms and positive initial conditions. (Received September 16, 2008)

1046-39-1755 **Saber N Elaydi*** (selaydi@trinity.edu), One Trinity Place, Trinity University, San Antonio, TX 78212. *Unimodal periodic models with Allee effects.* Preliminary report.

We will present a general frame work for biological models described by fintely many unimodal maps with Allee effects. Questions of stability, periodicity will be investigated. The main tools of study are skew-product systems, Liapunov exponenets and topological entropy. (Received September 16, 2008)

1046-39-1781 **Rebecca Burton Kalhorn***, North Carolina State University, Department of Mathematics, Box 8205, Raleigh, NC 27695, and **Jesus Rodriguez**. *Weakly Nonlinear Boundary Value Problems on Time Scales.*

We analyze weakly nonlinear boundary value problems on time scales. Our focus is problems at resonance, or where the solution space of the corresponding homogeneous linear boundary value problem is nontrivial. Conditions for the existence of solutions are presented as well as a discussion of parameter dependence of these solutions. (Received September 16, 2008)

1046-39-1864 **Saber N Elaydi*** (selaydi@trinity.edu), One Trinity Place, Trinity University, Department of Mathematics, San antonio, TX 78212. *Periodic difference equations with Allee effects: applications to economics and biology.* Preliminary report.

We will survey some of the new developments in modeling systems exhibiting Allee effects. In particular, we study periodically forced models in both economics and biology. (Received September 16, 2008)

1046-39-1890 **Kenneth S. Berenhaut** (berenhks@wfu.edu), Department of Mathematics, Wake Forest University, Winston-Salem, NC 27109, and **Nathaniel G Vish*** (vishng7@wfu.edu), Department of Mathematics, Wake Forest University, Winson-Salem, NC 27109. *Equations of convolution type with monotone coefficients.*

In this talk we consider convolution type linear difference equations with coefficients satisfying some monotonicity properties. Methods from renewal theory are employed to obtain easily verified conditions for asymptotic stability of the zero solution, in terms of the coefficient sequence. Explicit bounds and rates of convergence are considered, and an application to matrix inverses is included. Some related equations are also discussed. (Received September 16, 2008)

1046-39-1963 **Richard T Guy*** (guyrt7@wfu.edu), Department of Mathematics, Wake Forest University, Winston-Salem, NC 27109, and **Kenneth S Berenhaut** (berenhks@wfu.edu), Dept. of Mathematics, Wake Forest University, Winston-Salem, NC 27109. *Symmetric functions and difference equations with asymptotically periodic solutions.*

In this talk we employ symmetric functions to develop easily verified conditions which guarantee that all solutions to the equation $y_n = f(y_{n-k}, y_{n-m})$, with $k, m \geq 1$ and $\gcd(k, m) = 1$ are asymptotically periodic with period two. Asymptotic stability and complex periodic stucture for more general equations involving multiple delays is also considered. Several examples involving ratios are presented. In addition, we present generalizations to minimum difference equations and introduce some open questions. (Received September 16, 2008)

40 ► Sequences, series, summability

1046-40-522 **Thomas J Osler*** (osler@rowan.edu), Mathematics Department, Rowan University, Glassboro, NJ 08028. *Morphing Lord Brouncker's Continued Fraction for pi into the product of Wallis.*

We show that both Brouncker's continued fraction for pi and the product of Wallis (both from 1656) are special cases of a more general formula of the form 4/pi = BW(n), where n = 0, 1, 2, 3, etc . When n = 0 the expression 4/pi = BW(0) is the original continued fraction of Brouncker. As n approaches infinity, the formula becomes the original product of Wallis. When the expressions BW(1), BW(2), BW(3), etc. are listed, we see Brouncker's continued fraction gradually "morph" into Wallis's product.

Similar results are shown for other continued fractions similar to Brouncker's such as the one given recently by Lange [1]. We also discuss the observation of Stedall [2] that a large class of continued fractions for pi were known to both Wallis and Brouncker, but this fact seems to have been overlooked by modern mathematicians.

[1] Lange, L. J., An Elegant Continued Fraction for pi , The American Mathematical Monthly, 106 (1999), pp. 456-458.

[2] Stedall, Jacqueline A., Catching Proteus: The Collaborations of Wallis and Brouncker. I. Squaring the Circle, Notes and Records of the Royal Society of London, Vol. 54, No. 3, (Sep., 2000), pp. 293 -316 (Received September 05, 2008)

1046-40-534 **Ibrahim Canak*** (ibrahimcanak@yahoo.com), Adnan Menderes University, Faculty of Science and Letters, Department of Mathematics, 09010 Aydin, Turkey, and **Umit Totur**, Adnan Menderes University, Faculty of Science and Letters, Department of Mathematics, 09010 Aydin, Turkey. *Some conditions for convergence and subsequential convergence of regularly generated sequences.*

Let (u_n) be a sequence, regularly generated by a sequence $(alpha_n)$ where either $(alpha_n)$ or $(Deltaalpha_n) = (alpha_n - alpha_{n-1})$ is moderately oscillating. We investigate conditions under which the sequence (u_n) converges or converges subsequentially. (Received September 10, 2008)

1046-40-606 **Khrystyna Kuchmins'ka*** (kuchmin@lms.lviv.ua), Pidstryhach Institute of Applied Problems of, Mechanics and Mathematics of NASU, 3-B Naukova street, L'viv, 79060. *Some Types of Multi-Dimensional Continued Fractions.* Preliminary report.

Let consider multi-dimensional continued fractions (MDCFs) with equal variables: branched continued fractions (BCFs), two-dimensional continued fractions (TDCFs),and with unequal variables. Such MDCFs can be obtained from the formal multivariate power series. In convergence investigation of MDCFs special methods depending on the type of MDCF are used. For MDCFs with complex elements one can use the majorant method and the difference formula for approximants of the MDCF, the method, based on the Stieltjes-Vitali theorem, and the fundamental inequalities method; for MDCFs with positive elements the special inequalities are proposed. For the MDCF we have different kinds of approximants, depending on the length of branches of such fraction, appearing enough naturally. Connection between ordinary and figured approximants is also investigated for TDCFs. Despite that fact the most important criteria were proved for such fractions, the Paydon-Wall-like theorem was obtained recently. There are also many interesting unsolved problems,connecting with applying MDCFs to the number theory or find functional class of MDCFs with approximants, interpreted as multi-dimensional Pade approximants. These fractions can be applied to construction of multi-dimensional rational interpolants. (Received September 10, 2008)

1046-40-905 **Mokhtar Aouina*** (mokhtar.aouina@jsums.edu), Department of Mathematics, Jackson State University, Jackson, MS 39217, and **Mohammad Khadivi** (mohammad.reza.khadivi@jsums.edu), Depatment of Mathematics, Jackson State University, Jackson, MS 39217. *Treating Power Series Through Topoliogical Concepts.*

We will show how we can apply the essential topological ideas to power series in order to rectify the pitfalls related to the nth root test and the ratio test covered in calculus textbooks. We offer a new approach that will leads to the main theorem about the computation of the radius of convergence of any power series. In this talk, we adopted the Heine-Borel theorem as a definition for a compact set. We associated to a given sequence a closed set. The characterization of the aforementioned closed set results in retrieving Bolzano-Weierstrass theorem. The least upper bound of the closed set computes the radius of convergence of a power series with coefficients equal to the terms of the sequence respectively. We will present problems for which both nth root test and ratio test fail while our method will settle the domain of convergence. (Received September 12, 2008)

1046-40-1049 **Lisa Lorentzen*** (lisa@math.ntnu.no). *Some of Ramanujan's continued fraction identities - how and why.*

Ramanujan left a number of intriguing continued fraction identities at his untimely death, with no clues as to how he derived them. In this talk we give an idea on Ramanujan's reasoning behind his first continued fraction identities. This idea also provides an explanation for his choice of identities. (Received September 14, 2008)

1046-40-1793 **Douglas Bowman*** (bowman@math.niu.edu), Northern Illinois University, Mathematical Sciences, Watson Hall 320, DeKalb, IL 60115. *Sequential Closures of Continued Fractions.* Preliminary report.

In recent research the author has defined the sequential closure of a sequence, and applied this notion to sequences of approximants of continued fractions. In this talk, topological properties of sequential closures of sequences are described and some of their implications for the convergence theory of continued fractions are given. This yields an extension of previous theory (by the author and J. McLaughlin) from l_1 limit 1-periodic continued fractions to l_1 limit k-periodic continued fractions. Also described is a useful theorem which allows one to compute sequential closures of continued fractions by a method related in theme to the Pincherle theorem. This leads to explicit evaluations of sequential closures of continued fractions of greater generality than was possible by the previous method.

The upshot is that one can tame the divergence of continued fractions when their terms are l_1 perturbations of periodic continued fractions. Among other results this yields a complete characterization of the limiting behavior of q-continued fractions, when $|q| \neq 1$, described by the author and K. Campbell. The fundamental results hold for more general sequences, and in particular for products of elements in unital Banach algebras. Future directions are indicated. (Received September 16, 2008)

1046-40-1825 **Mihaela Dobrescu*** (mihaela.dobrescu@cnu.edu), 1 University Place, Math Dept, Newport News, VA 23606. *A new look at the convergence of a famous sequence.* Preliminary report.

The first known references to e were found in a work of John Napier from 1618, where e does not show up explicitly, but in a list of logarithms written in an appendix probably by William Oughtred. Jacob Bernoulli is the one believed to have found the constant itself while attempting to find the limit $\lim_{n\to\infty}(1+\frac{1}{n})^n$. Gottfried Leibniz and Christiaan Huygens have used the constant around 1690 representing it by the letter b. Finally Leonhard Euler publishes his work *Mechanica* in 1736 and the constant gets its name, e.

Most of the today calculus books define e as being the positive real number such that $\ln e = \int_1^e \frac{1}{t}dt = 1$. Starting from this definition, we give a new proof for the convergence of $\{(1+\frac{1}{n})^n\}_n$ as a particular case of a family of sequences $\{(1+\frac{1}{n})^{n+\epsilon}\}_n$ converging to e. We believe that the new proof of the monotonicity of this family of sequences will be one accessible to students in their first semester of calculus. (Received September 16, 2008)

1046-40-1975 **Constantine Georgakis*** (cgeorgak@condor.depaul.edu), Department of Mathematics, DePaul University, 2320 North Kenmore Ave., Chicago, IL 60614-, IL. *Reverse Sharp Inequalities for the Sequence-to- Function Hausdorff Transformation.* Preliminary report.

In Proc.Amer.Math.Soc. Vol. 103 (1988), pp. 531-542, the author established a sharp inequality for the sequence-to-function Hausdorff transformation and its adjoint, which are generated by a completely monotone function, as mappings between the Lp space with power weighted norm to the sequence space lp with Pocchammer power weighted norm for p greater or equal to 1. A sharp analogue of this inequality is presented for the same transformation for positive functions and sequences in the case when p is between zero and 1 that leads to similar sharp inequalities for power series and moment sequences. The argument for the best constant is much different than that given in the cited paper and applies to the case when p is greater or equal to 1 as well. (Received September 16, 2008)

1046-40-2037 **Corneliu Alexandru Bodea*** (cornel.bodea@richmond.edu), 28 Westhampton Way, University of Richmond, UR 1552, Richmond, VA 23173, and **Matthew F Der** (matt.der@richmond.edu), **Calina Anamaria Copos** (calina.copos@richmond.edu) and **David O'Neal** (david.j.oneal@gmail.com). *Sequence Design in Wireless Communication.*

We provide new theorems that describe when two sequences have the same Non-Periodic Autocorrelation Function (NPAF). Knowledge of the NPAF can be used to determine the Peak-to-mean envelope power ratio (PMEPR), a key measure of the suitability of the sequence for use in the wireless transmission scheme known as Orthogonal Frequency Division Multiplexing (OFDM). This poster provides background on OFDM, a brief summary of recent work by Fiedler and Jedwab demonstrating the importance of knowledge of "Shared Autocorrelation Property", and an overview of our new results. We also include preliminary results of our search for new near-Golay sequences and other low power sequences. (Received September 16, 2008)

41 ► *Approximations and expansions*

1046-41-58 **George A Anastassiou*** (ganastss@memphis.edu), Department of Mathematical Sciences, University of Memphis, Memphis, TN 38152, **Oktay Duman** (oduman@etu.edu.tr), TOBB Economics and Technology University, Department of Mathematics, Ankara, Turkey, and **Esra Erkus-Duman** (eduman@gazi.edu.tr), Gazi University, Department of Mathematics, Ankara, Turkey. *Statistical Approximation for Stochastic Processes.*

In this work we obtain strong Korovkin-type approximation theorems for stochastic processes by using the concept of A-statistical convergence from summability theory. One application of our results,when A=I the infinite identity matrix, recovers earlier results of the first author regarding Korovkin type Approximation theory for Stochastic Processes with respect to Lp norm. (Received July 16, 2008)

1046-41-331 **Martin Bartelt*** (mbartelt@pcs.cnu.edu), Mathematics Department, Christopher Newport University, Newport News, VA 23606, and **John Swetits** (jswetits@odu.edu), Department of Mathematics and Statistics, Old Dominion University, Norfolk, VA 23529. *Functions with strongly unique best approximates are dense in vector valued approximation.*

H. Blatt showed that in uniform approximation from a Haar set of dimension n in C(X), for X a compact subset of the complex plane, the set of functions which have a reference of minimal length 2n+1 is dense in C(X) if and only if X has at most n isolated points. These minimal length reference functions all have strongly unique best approximates. We extend this result to uniform vector valued approximation in C(X,R^m) for a generalized Haar set in the case when n = mk. (Received August 26, 2008)

1046-41-473 **Mark A. Kon** (mkon@bu.edu), Department of Mathematics and Statistics, Boston University, Boston, MA 20059, and **Louise A. Raphael*** (lraphael@howard.edu), Department of Mathematics, Howard University, Washington, DC 20059. *Statistical Learning Methods for Uniform Approximation Bounds in Multiresolution Spaces.*

New constructive and non-constructive non-asymptotic uniform error bounds for approximating functions in $\mathcal{L}^2_s(\mathbb{R}^d)$, $d \geq 1$, by finite compactly supported multiresolution expansions are proved using approximation theoretic bounds derived from statistical learning theory. (Received September 04, 2008)

1046-41-572 **Edward J Fuselier*** (edward.fuselier@usma.edu), Department of Mathematical Sciences, United States Military Academy, West Point, NY 10996, and **Grady B Wright** (wright@math.boisestate.edu), Department of Mathematics, Boise State University, Boise, ID 83725. *Vector Field Decomposition on the Sphere using Radial Basis Functions.*

A new numerical technique based on radial basis functions (RBFs) will be presented for fitting a vector field tangent to the sphere, $\mathbb{S}^2$, from samples of the field at "scattered" locations on $\mathbb{S}^2$. The method naturally provides a way to decompose the reconstructed field into its individual Helmholtz-Hodge components, i.e. into divergence-free and curl-free parts, which is useful in many applications from the atmospheric and oceanic sciences. Several approximation results for the method will be presented. In particular, Sobolev-type error estimates are obtained for both the interpolant and its decomposition. Optimal stability estimates for the associated interpolation matrices will also be presented. Finally, numerical validation of the theoretical results will be given for vector fields with similar characteristics to those of atmospheric wind fields. (Received September 08, 2008)

1046-41-595 **Vasiliy A. Prokhorov*** (prokhoro@jaguar1.usouthal.edu), Department of Mathematics and Statistics, ILB 325, University of South Alabama, Mobile, AL 36688, and **Dmitri V. Prokhorov** (dprokhor@shell.cas.usf.edu), Department of Mathematics and Statistics, 4202 East Fowler Ave, PHY114, University of South Florida, Tampa, FL 33620-5700. *On some bilinear symmetric forms and meromorphic continuation of analytic functions.* Preliminary report.

Let f be a function analytic in the open disk $\{z : |z| < R\}, R > 1$. In this talk we consider a bilinear symmetric form defined on the class of polynomials of degree at most m:

$$[u, v] = \frac{1}{2\pi i} \int_{\Gamma} \frac{(uvf)(t)dt}{t^{n+m}}, \ \deg u \leq m, \quad \deg v \leq m,$$

where Γ is the unit circle with center at zero and n is a nonnegative integer. Let $\langle u, v \rangle$ be the inner product in the space $L_2(\Gamma)$. There are the polynomials $Q_{k,n}$, $\deg Q_{k,n} \leq m$, $k = 0, \ldots, m$, characterized by the double orthogonality conditions:

$$[Q_{i,n}, Q_{j,n}] = \lambda_{i,n}\delta_{ij}, \ \langle Q_{i,n}, Q_{j,n} \rangle = \delta_{ij},$$

where δ_{ij} is Kronecker's symbol and $\lambda_{0,n} \geq \ldots \geq \lambda_{m,n} \geq 0$ are the characteristic values of the bilinear symmetric form $[u, v]$. We investigated asymptotic behavior of $\lambda_{k,n}$, zeros of $Q_{k,n}$, and the connection of degree of convergence with meromorphic continuation of the function f in the case when k and m, $0 \leq k \leq m$, are fixed, and $n \to \infty$. (Received September 08, 2008)

1046-41-747 **William A. Massey*** (wmassey@princeton.edu), Department of Operations Research, and Financial Engineering, Princeton University, Princeton, NJ 08544. *Fluid limits, diffusion limits, and event horizons for the response times of processor sharing queues with time varying rates.*

We can determine the asymptotic behavior of the response time for a processor sharing queue when appropriately scaled. This is achieved by using the theory of strong approximations to do an asymptotic analysis of the random sample path behavior for the underlying queueing process. This analysis extends to queueing systems with time varying arrival rates. Finally new phenomena is discovered for such systems that we call the "event horizon" for a processor sharing queue. All these results are based on joint work with Robert Hampshire and Mor Harchol-Balter. (Received September 10, 2008)

1046-41-803 **Esfandiar NAVA-YAZDANI*** (navayazd@gmx.de), 3141 Chestnut St, Korman Center 209, Philadelphia, PA 19104. *On Smoothness of Nonlinear Subdivision Schemes.*

There has been a growing interest in multiscale resolution of nonlinear data in the recent years. A significant issue therein is smoothness. In the present work we consider subdivision of manifold valued data. The notion of those subdivision schemes based on an appropriate linear one will be in a general setting such that known examples like subdividing by means of geodesic averaging in Riemannian manifolds, log-exponential subdivision schemes in Lie groups and those induced in symmetric spaces are covered. We investigate smoothness of these constructions and applications in dynamics of rigid body and difussion tensors.
(Received September 11, 2008)

1046-41-971 **Yang Chen*** (y.chen@imperial.ac.uk), Imperial College London, 180 Queen's Gate, London, SW7 2BZ, England. *Some linear statistics of random Hermitean matrices that are Painlevé functions.*

The sum of functions of random variables known as linear statistics is a stochastic variable of frequent occurrences in random matrix theory. In this talk, I will provide examples of families of linear statistics that are expressed in terms of Painlevé functions. These are derived via the basic theory of orthogonal polynomials. (Received September 13, 2008)

1046-41-1246 **Alfred S. Cavaretta** (cavarett@math.kent.edu), Department of Mathematics, Kent State University, Kent, OH 44240, and **Terence G. Hanchin*** (thanchin@kent.edu), Department of Mathematics, Kent State University, Kent, OH 44240. *A generalization of a result of G. Pólya and its application to a continuous extension of the de la Vallée Poussin means.*

The classical de la Vallée Poussin means provide a linear approximation method which is variation diminishing and therefore 'shape preserving'. We will show that this classical result of G. Pólya and I.J. Schoenberg holds also for a wider class of means whose periodic kernels $(1+\cos t)^{\lambda}, \lambda = \frac{1}{2}+n, n \in \mathbb{N}$, have been singled out for study in a 2003 paper of S. Ruscheweyh and T. Suffridge. On the real axis, there are related variation diminishing properties of the functions $u^m \mathrm{sgn} u$, which are the Green's functions for the differential operator $D^{(m+1)}$. Work on this problem leads to an interesting variant of old results of Sylvester and Pólya. (Received September 15, 2008)

1046-41-1304 **Alexander Its*** (itsa@math.iupui.edu), The Department of Mathematical Sciences, IUPUI, 402 N. Blackford Street, LD270, Indianapolis, IN 46202-3216. *Global asymptotic analysis of the Painlevé transcendents. The Riemann-Hilbert Approach.*

In this talk we will review some of the global asymptotic results obtained during the last two decades in the theory of the classical Painlevé equations with the help of the Isomonodromy - Riemann-Hilbert method. The results include the explicit derivation of the asymptotic connection formulae, the explicit description of linear and nonlinear Stokes phenomenon and the explicit evaluation of the distribution of poles. We will also discuss some of the most recent results emerging due to the appearance of Painlevé equations in random matrix theory. The Riemann-Hilbert method will be outlined as well. (Received September 15, 2008)

1046-41-1318 **Alfred S. Cavaretta*** (cavarett@math.kent.edu), Department of Mathematics, Kent State University, Kent, OH 44240, and **Terence Hanchin**. *A context for Sylvester's theorem on sums of shifted monomial powers.* Preliminary report.

Commenting on a 1914 paper of G. Pólya in 1974, I. J. Schoenberg claimed that this particular theorem of Sylvester was an "interesting but isolated result." In 1958 Schoenberg and Pólya used the theorem to establish the cyclic variation diminishing property of the de la Vallée Poussin means. While studying this property for a wider class of means, we have found that Sylvester's theorem is itself just one instance of a wider class of such results. (Received September 15, 2008)

1046-41-1474 **Patricia Mellodge*** (mellodge@hartford.edu), 200 Bloomfield Avenue, CETA, West Hartford, CT 06117, and **S. S. Townsend**. *Approximating Bessel Functions of the First Kind Using Super-Gaussians.*

This work addresses the approximation of the Bessel function $J_m(x)$ of integer order and real argument using the exponentials $e^{-a_n x^n}$. This generalized form of the Gaussian function is known as a super-Gaussian in the optics community. The objective is to approximate the Bessel function using a configuration that converges more rapidly and is more computationally efficient than the well known series expansion for small arguments. For $x < m$, the approximation takes the form $x^m e^{-H_m(x)}$, where $H_m(x)$ is an infinite series containing nonnegative even powers of x. The coefficients of powers of x are given by a recursive relationship where the first coefficient is an overall scaling factor and the second coefficient corresponds to the optimal value for Gaussian approximation. This recursion can be expressed as a finite convolution sum. Truncating $H_m(x)$ to a finite series introduces an error in the approximation that becomes larger as x approaches m. Analysis is given and numerical results are provided that indicate the relationship between the number of terms in $H_m(x)$ used and error introduced. (Received September 15, 2008)

1046-41-1541 **Isao Yamada*** (isao@comm.ss.titech.ac.jp), Dept of Communications and Integrated Sys, Tokyo Institute of Technology, S3-60, Ookayama, Meguro-ku, Tokyo, 152-8550, and **Tomasz Piotrowski** (tpiotrowski@comm.ss.titech.ac.jp), Dept of Communications and Integrated Sys, Tokyo Institute of Technology, S3-60, Ookayama, Meguro-ku, Tokyo, 152-8550. *Minimum-Variance Pseudo-Unbiased Reduced-Rank Estimator and Its Applications.*

We introduce central idea of the MV-PURE (Minimum-Variance Pseudo-Unbiased Reduced-Rank Estimator), by Yamada and Elbadraoui (2006), by Piotrowski and Yamada (2008), which was established recently as a novel robust estimator for ill-conditioned linear inverse problems. The MV-PURE is defined as a closed form solution of a hierarchical nonconvex constrained optimization problem and achieves the minimum variance among all solutions of the first stage optimization problem for minimizing, under a rank constraint, simultaneously all unitarily invariant norms of an operator applied to the unknown parameter vector in view of suppressing bias of the estimator. The MV-PURE is a unified extension of well-known estimators: the Gauss-Markov estimator (BLUE: Best Linear Unbiased Estimator), the generalized Marquardt's reduced-rank estimator and the Chipman's minimum-variance conditionally unbiased affine estimator subject to linear restrictions. The remarkable applicability of the MV-PURE is found not only in a broad range of ill-conditioned inverse problems (e.g., an interpolation in reproduction kernel Hilbert space) but also in certain stochastic estimations of random vectors under imperfect model knowledge (e.g., a linear detection in a MIMO wireless communication systems). (Received September 16, 2008)

1046-41-1679 **Valerio De Angelis*** (vdeangel@xula.edu), Mathematics Department, Xavier University of Louisiana, 1, Drexel Drive, New Orleans, LA 70125. *Another look at the Stirling series.*

We present a concise and elementary derivation of the complete asymptotic expansion for the factorial function $n!$, that we will refer to as the Stirling's series. While there have been numerous published proofs of the Stirling's series and of its classical dominant term given by Stirling's formula

$$\lim_{n\to\infty} \frac{n!e^n}{n^n\sqrt{2\pi n}} = 1,$$

the present treatment produces some new expressions for the coefficients. In addition, it brings to light the simple relationship between the asymptotic expansions of $n!$ and $1/n!$ that, even though easily derived from the well-known expansion of $\log\Gamma(z)$ in terms of the Bernoulli numbers, seems to have no simple published proof. (Received September 16, 2008)

1046-41-1887 **Mahmoud H. Annaby*** (mhannaby@yahoo.com), Department of Mathematics, Faculty of Science-Cairo University, Giza, 12613, Egypt, and **Zeinab S. Mansour** (zeinabs98@hotmail.com), Department of Mathematics, Faculty of Science-Cairo University, Giza, 12613, Egypt. *Asymptotic formulae for eigenvalues and eigenfunctions of q-Sturm-Liouville problems.*

We investigate the asymptotic behavior of the eigenvalues and the eigenfunctions of $q-$Sturm-Liouville eigenvalue problems. For this aim we study the asymptotic behavior of $q-$trigonometric functions as well as fundamental sets of solutions of the associated second order $q-$difference equation. As in classical Sturm-Liouville theory, the eigenvalues behave like zeros of $q-$trigonometric functions and the eigenfunctions behave like $q-$trigonometric functions. (Received September 16, 2008)

1046-41-2040 **maki iwami*** (pseudoinitial@gmail.com), Osaka University of Economics and Law, 6-10 Gakuonji, Yao, Osaka 5818511, Japan. *Applying expansion techniques of multivariate expansion base method and extended Hensel construction to cryptography.* Preliminary report.

Multivariate expansion base method is used for multivariate analytic factorization, i.e. factorization over the ring of formal power series fixing the expansion point, and extended Hensel construction is the Hensel construction

at a singular point. I'll talk about possibilities for applying their expansion techniques to cryptography using multivariate polynomials. (Received September 16, 2008)

1046-41-2128 **Edward B. Saff*** (edward.b.saff@Vanderbilt.Edu), Department of Mathematics, Vanderbilt University, 1326 Stevenson Center, Nashville, TN 37240, **Johann S. Brauchart** (johann.brauchart(at)TUGraz.at), Graz University of Technology, Rechbauerstr. 12, Graz, 8010, and **Douglas Hardin** (doug.hardin@vanderbilt.edu), Department of Mathematics, Vanderbilt University, Nashville, TN 37240. *The Riesz Energy of the N-th Roots of Unity: An Asymptotic Expansion for Large N.*

We derive the complete asymptotic expansion in terms of powers of N for the Riesz s-energy of N equally spaced points on the unit circle as $N \to \infty$. For $s \geq -2$, such points form optimal energy N-point configurations with respect to the Riesz potential $1/r^s, s \neq 0$, where r is the Euclidean distance between points. By analytic continuation we deduce the expansion for all complex values of s. The Riemann zeta plays an essential role in this asymptotic expansion. (Received September 26, 2008)

42 ► Fourier analysis

1046-42-68 **William O. Bray*** (bray@math.umaine.edu), Department of Mathematics and Statistics, University of Maine, 333 Neville Hall, Orono, ME 04469. *Growth properties of Fourier transforms via moduli of continuity.*

A classical theme in harmonic analysis is embodied in the statement: behavior of the modulus of continuity of a function for small parameter reflects in the behavior of the Fourier transform for large parameter. In this talk we present weighted estimates of Fourier transforms in terms of an L^p-modulus of continuity defined using spherical means. The viewpoint will be carried out in Euclidean space and rank one symmetric spaces of non-compact type (joint work with M.A. Pinsky, to appear in the Jour. Func. Anal.). I will also present progress in this vein in the realm of general symmetric spaces of Euclidean type and non-compact type. (Received July 20, 2008)

1046-42-163 **Mark A. Pinsky*** (mpinsky@math.northwestern.edu), Mathemaatics Department, Northwestern University, 2033 Sheridan Rd., Evanston,, IL 60208-2730. *Pointwise convergence of fourier series of the indicator of a ball in euclidean space, following Kuratsubo.*

Following earlier joint work of the author (JFA, 1993), Kuratsubo has established a complete result concerning the pointwise convergence of the spherical partial sums of the Fourier series of the indicator function of a d-dimensional ball in Euclidean space. The results depend on the dimension and the point at which the sums are computed.The method of proof depends on some new lattice point estimates due to Breislav Novak. (Received August 08, 2008)

1046-42-511 **Diego Maldonado** and **Virginia Naibo*** (vnaibo@math.ksu.edu), Kansas State University, Mathematics Department, 138 Cardwell Hall, Manhattan, KS 66506. *Besov-Lebesgue mapping properties for bilinear operators.* Preliminary report.

We discuss Besov-Lebesgue mapping properties of the form $\dot{B}_p^{\alpha,s} \times L^q \to \dot{B}_r^{\alpha,s}$ for families of bilinear operators, including molecular paraproducts and Hörmander-Mihlin multipliers, and their connections with bilinear Littlewood-Paley theory. (Received September 05, 2008)

1046-42-743 **Emanuel Carneiro*** (ecarneiro@math.utexas.edu), University of Texas at Austin, Department of Mathematics, Austin, TX. *A sharp inequality for the Stricharz norm.* Preliminary report.

Let $u : \mathbb{R} \times \mathbb{R}^n \to \mathbb{C}$ be the solution of the linear Schrodinger equation

$$\begin{cases} iu_t + \Delta u & = & 0 \\ u(0,x) & = & f(x). \end{cases}$$

We obtain an a priori sharp inequality for the Strichartz norm $\|u(t,x)\|_{L_t^{2k}L_x^{2k}(\mathbb{R}\times\mathbb{R}^n)}$, where $k \in \mathbb{Z}$, $k \geq 2$ and $(n,k) \neq (1,2)$, that admits only gaussian maximizers. As corollaries we present sharp forms of the classical Stricharz inequalities in low dimensions (works of Foschi and Hundertmark-Zharnitsky) and also sharp forms of some Stricharz-Sobolev inequalities. (Received September 10, 2008)

1046-42-934 **Kabe Moen**, **Carlos Pérez** and **Rodolfo H. Torres*** (torres@math.ku.edu). *Sharp weighted bounds for fractional operators.*

We examine the relationship between the $A_{p,q}$ constant of a weight w and the operator norms of some classical operators from $L^p(w^p)$ to $L^q(w^q)$. We obtain sharp bounds for the fractional integral operator I_α and associated fractional maximal function M_α. As an application we consider a sharp Poincaré-type inequality. (Received September 12, 2008)

1046-42-1064 **Kabe A. Moen*** (moen@math.ku.edu), Department of Mathematics, University of Kansas, Snow Hall, Lawrence, KS 66045-7523. *Weighted Inequalities for Multilinear Fractional Integral Operators.*

A weighted theory for multilinear fractional integral operators and maximal functions is presented. Sufficient conditions for the two weight inequalities of these operators are found, including "power and logarithmic bumps" and an A_∞ condition. For one weight inequalities a necessary and sufficient condition is then obtained as a consequence of the two weight inequalities. As an application, Poincaré and Sobolev inequalities adapted to the multilinear setting are presented. (Received September 14, 2008)

1046-42-1120 **Tristan Collins** and **Malabika Pramanik*** (malabika@math.ubc.ca), 1984 Mathematics Road, University of British Columbia, Vancouver, BC V6T 1Z2, Canada. *Critical integrability exponent associated to multivariate polynomials.*

We discuss local integrability issues (near the origin) for integrands of the form $|f|^{-\delta}$, where f is a multivariate polynomial vanishing at the origin. Using a resolution of singularities algorithm we obtain a description of the critical integrability exponent δ in terms of Newton data associated to f. (Received September 14, 2008)

1046-42-1177 **Leonid Slavin*** (leonid@math.missouri.edu). *Bellman function in non-local settings.* Preliminary report.

In recent years, an improved Bellman methodology has led to many new explicit Bellman functions in important applications. However, these new findings have been restricted to local and semi-local settings (such as the exponential integral and the dyadic maximal operator, respectively). In this talk, we discuss possible non-local applications, such as the norms of Fourier multipliers on L^p and BMO. (Received September 15, 2008)

1046-42-1290 **Ciprian Demeter*** (demeterc@indiana.edu), Indiana University, Dept. of Mathematics, 831 East 3rd St., Bloomington, IN 47405. *Maximal multipliers in L^p.*

We extend an L^2 maximal multiplier result of Bourgain to all L^p spaces, $1 < p < \infty$. (Received September 15, 2008)

1046-42-2096 **Alex Iosevich*** (iosevich@math.missouri.edu), 5008 Forum Blvd., Columbia, MO 65203. *Geometric configurations in Euclidean space and restriction theory.*

We will show how Fourier analysis and geometric combinatorics can be combined to yield results about geometric configurations in large subsets of the Euclidean space and vector spaces over finite fields. (Received September 17, 2008)

1046-42-2118 **J. Marshall Ash*** (mash@math.depaul.edu), Mathematics Department, DePaul University, Chicago, IL 60614, **Sergey Tikhonov**, Scuola Normale Superiore, and **James Tung**, DePaul University. *A generalization of an unpublished theorem of Wiener*

There is a well known but unpublished theorem of Norbert Wiener that asserts that if a function has nonnegative Fourier coefficients and is square integrable in a neighborhood of the origin, then it is square integrable on the entire torus. This result has a very simple proof. Over the years, various generalizations have been found. Also similar situations where the result is not true have been discovered. We find a fairly broad generalization here which appears to be the right statement to fit the original proof. (Received September 19, 2008)

43 ► Abstract harmonic analysis

1046-43-86 **Taylor Edward Burmeister*** (tburmeis@haverford.edu), c/o Haverford College, 370 Lancaster Avenue, Haverford, PA 19041. *Local Edge Detection with Wavelet Coefficients.*

We will provide a quick introduction to wavelet series and explore some analysis of wavelet coefficients that may be used in developing an effective method of edge detection with wavelets. Shlomo Engelberg recently published a paper on edge detection using Fourier coefficients, wherein he showed how to determine the continuity of a function based on the absolute summability of its Fourier coefficients and demonstrated a method of identifying jump discontinuities and their heights from a functions Fourier coefficients. We will explore some similar results with wavelet coefficients. Specifically, we will look at what happens to the wavelet coefficients over a point if the function jumps at that point and relate the absolute summability of a function's wavelet coefficients at a point or on an interval with its continuity at that point or on the interval. Further, we will compare wavelets with Fourier series as a tool for edge detection. (Received July 22, 2008)

1046-43-879 **Norbert N Youmbi*** (nyoumbi@francis.edu), Department Mathematical Sciences, 117 Evergreen Dr, Sullican 114, Loretto, PA 15940. *Idempotent probability measures on a locally compact semihypergroups.*

A semihypergroup is obtained by dropping the requirement of and involution and an identity element from the definition of a hypergroup. A regular semihypergroup is a hypegroup in which the algebraic property of involution is not required. An idempotent probability measure on a locally compact semigroup is supported by a completely simple semigroup and in a commutative case by a compact group. This result does not hold for semihypergroup in general. We give an example of an idempotent probability measure on a finite semihypergroup which is not supported by a completely simple semihypergroup. We show that under some mild conditions, the support of an idempotent probability measure is a compact simple semihypergroup. If further the support of an idempotent probability measure contains an idempotent element it will be a compact regular semihypergroup.
(Received September 12, 2008)

1046-43-1532 **John J Benedetto** (jjb@math.umd.edu), Department of Mathematics, Mathematics Building, University of Maryland, College Park, MD 20742-4015, and **Emily J King*** (eking@math.umd.edu), Department of Mathematics, Mathematics Building, University of Maryland, College Park, MD 20742-4015. *Smooth functions associated with wavelet sets on $\mathbb{R}^d$, $d \geq 1$, and frame bound gaps.*

The theme is to smooth characteristic functions of Parseval frame wavelet sets by convolution in order to obtain implementable, computationally viable, smooth wavelet frames. We introduce the following: a new method to improve frame bound estimation; a shrinking technique to construct frames; and a nascent theory concerning frame bound gaps. The phenomenon of a *frame bound gap* occurs when certain sequences of functions, converging in L^2 to a Parseval frame wavelet, generate systems with frames bounds that are uniformly bounded away from 1. We prove that smoothing a Parseval frame wavelet set wavelet on the frequency domain by convolution with elements of an approximate identity produces a frame bound gap. Furthermore, the frame bound gap for such frame wavelets in $L^2(\mathbb{R}^d)$ increases and converges as d increases. (Received September 15, 2008)

44 ► Integral transforms, operational calculus

1046-44-1483 **Elena Ournycheva***, 300 Campus Drive, Bradford, PA 16701. *Erdélyi-Kober integrals on the cone of positive definite matrices and Radon transforms on Grassmann manifolds.*

We introduce bi-parametric fractional integrals of the Erdélyi-Kober type that generalize known Gårding-Gindikin constructions associated to the cone of positive definite matrices. It is proved that the Radon transform, which maps a zonal function on the Grassmann manifold $G_{n,m}$ of m-dimensional linear subspaces of R^n into a function on the similar manifold $G_{n,k}$, $1 \leq m < k \leq n-1$, is represented as analytic continuation of the corresponding Erdélyi-Kober integral. This result shows that different Grinberg-Rubin's formulas for such transforms have, in fact, a common structure. (Received September 15, 2008)

1046-44-1497 **Anna Amirdjanova*** (anutka@umich.edu), 439 West Hall, 1085 S. University Avenue, Ann Arbor, MI 48109. *Stochastic Feynman integral: Perspectives from fractional stochastic calculus.* Preliminary report.

This work is devoted to the analysis of properties of stochastic Feynman integrals, where the latter are defined using abstract Wiener spaces associated to fractional Brownian motions of various Hurst indices. These results utilize a number of tools from fractional stochastic integration and the theory of Gaussian processes, which will also be discussed in some detail. (Received September 15, 2008)

45 ► Integral equations

1046-45-426 **Volker Michel***, University of Siegen, Emmy-Noether-Campus, Walter-Flex-Strazße 3, 57068 Siegen, Germany. *On some mathematical aspects of the ill-posed determination of the Earth's interior.*

The determination of the Earth's interior is a typical example of an ill-posed inverse problem. The available data are of various types: e.g. (terrestrial, airborne, and spaceborne) gravitational data, earthquake travel times, and normal mode anomalies. The available rheological quantities are the mass density and the speeds of P and S waves. From the mathematical point of view, different examples of Fredholm integral equations of first kind are involved. In this talk, selected theoretical and numerical aspects of the involved problems (in particular, the inversion of gravitational data and travel times) are discussed. Briefly, normal mode tomography is mentioned. Moreover, some open problems are pre-sented. (Received September 02, 2008)

1046-45-1484 **Cara D. Brooks*** (brooks1@rose-hulman.edu), 5500 Wabash Ave. CM 139, Terre Haute, IN 47803, and **Patricia K. Lamm**. *Extensions to the theory of local regularization for solving linear Volterra inverse problems.* Preliminary report.

We extend the theory of local regularization for solving linear, first kind Volterra convolution equations with finitely smoothing kernels to allow for the underlying data spaces $L^p[0,1], 1 < p < \infty$. To do so, modifications must be made to the conditions established by P.K. Lamm for convergence with data in $C[0,1]$. This includes specifying appropriate families of signed measures appearing in the second-kind Volterra equation associated with local regularization and giving further conditions to guarantee well-posedness of the equation for all values of the regularization parameter in a designated interval. We prove that these modifications are sufficient to ensure that solutions to the second-kind Volterra equation, based on exact data, converge to the problem's true solution in $L^p[0,1]$. We also provide an *a priori* parameter selection strategy so that solutions, based on inexact data, converge to the problem's true solution in $L^p[0,1]$ as the noise level and regularization parameter shrink to zero, i.e. the resulting local regularization method is L^p-convergent. Furthermore, we establish a rate of L^p-convergence of approximations satisfying the source condition of uniform Hölder continuity. (Received September 15, 2008)

46 ► Functional analysis

1046-46-149 **Berhanu T Kidane*** (berha001@bama.ua.edu), 319 Grace street Apt 38, Tuscaloosa, AL 35401, and **Tavan T Trent** (ttrent@as.ua.edu), Department Mathematics, The University of Alabama, Box 870350, Tuscaloosa, AL 35487. *The Corona Theorem for Infinitely Many Functions on the Multiplier Algebra of the Weighted Dirichlet Spaces.*

In this talk, we prove the Corona Theorem on the multiplier algebra of the Weighted Dirichlet Spaces (D_α) for infinitely many functions, for the weight $\alpha \in (0,1)$. The main outline of the proof goes as follows: first, we find estimates for the weighted Dirichlet norm that is expressed on the boundary of the unit circle, which basically enable us to extend multipliers on the weighted Dirichlet Spaces to multipliers on weighted Harmonic Dirichlet Spaces. Subsequently, using techniques employed by Tavan Trent to prove the Corona Theorem for infinitely many functions from the multiplier algebra on Dirichlet Space (un-weighted), we prove the (D_α) Corona Theorem. (Received August 06, 2008)

1046-46-178 **Cecile M DeWitt-Morette*** (cdewitt@physics.utexas.edu), The University of Texas at Austin, Dept of Physics, 1 University Station C1600, Austin, TX 78712-0268. *The Power of Functional Integration.*

Since 1948 I have enjoyed the power of functional integration in physics, but I have been frustrated by its limited usage. Functional integration is a versatile mathematical tool that improves with usage. It is versatile because it is defined on function spaces. It often begins with a heuristic application, but a heuristic result is the tip of an iceberg, it indicates the existence of a not-yet-explored mathematical structure, it offers the opportunity to create a new branch of pure mathematics out of a problem of applied science.

I shall give a list of physics problems to which functional integration has made, or could make, substantial contributions. The list begins with problems discussed by Dyson in his 1972 Gibbs lecture "Missed Opportunities" and goes to recent problems in Quantum Gravity. It will include some of the projects presented in the last chapter of a recent book "Functional Integration, Action and Symmetries" by Pierre Cartier and CDW. (Received August 12, 2008)

1046-46-243 **Dietmar Bisch*** (dietmar.bisch@vanderbilt.edu), Vanderbilt University, Department of Mathematics, SC 1326, Nashville, TN 37240. *The Free Product of Planar Algebras.*

Given two planar algebras $\mathfrak{A}$ and $\mathfrak{B}$, one can define a new planar algebra $\mathfrak{A} * \mathfrak{B}$, the *free product* of $\mathfrak{A}$ and $\mathfrak{B}$. We explain this construction and discuss properties of this planar algebra. Applications to the structure theory of subfactors will be presented as well. This is joint work with Vaughan Jones. (Received August 22, 2008)

1046-46-246 **Weihua Li*** (whli@unh.edu), Department of Mathematics and Statistics, Kingsbury Hall, Durham, NH 03824, and **Don Hadwin**. *Some results on approximate liftings.*

We prove approximate lifting results in the C*-algebra and von Neumann algebra settings. In the C*-algebra setting, we show that two (weakly) semiprojective unital C*-algebras, each generated by n projections, can be glued together with partial isometries to define a larger (weakly) semiprojective algebra. In the von Neumann algebra setting, we prove lifting theorems for trace-preserving *-homomorphisms from abelian von Neumann algebras or hyperfinite von Neumann algebras into ultraproducts. We also extend a classical result of S. Sakai by showing that a tracial ultraproduct of C*-algebras is a von Neumann algebra, which yields a generalization of Lin's theorem on almost commuting self-adjoint operators with respect to $\|\cdot\|_p$ on any unital C*-algebra with trace. (Received August 22, 2008)

1046-46-294 **Rebekah B Yates*** (ryates@mso.umt.edu), University of Montana, Department of Mathematical Sciences, Math Building, Missoula, MT 59808. *Norm-linear Operators Between Uniform Algebras.*

Norm-linear mappings are mappings $T : A \to B$ between uniform algebras A and B such that $\|\lambda Tf + \mu Tg\| = \|\lambda f + \mu g\|$ for every $f, g \in A$ and every $\lambda, \mu \in \mathbb{C}$. We prove that norm-linear mappings which preserve the peripheral spectra of $\mathbb{C}$-peaking functions are algebra isomorphisms. Along the way, we prove a generalization of a classical theorem of Bishop and derive previous results as corollaries. (Received August 25, 2008)

1046-46-307 **Minakshisundaram ——— Rajagopalan*** (mrajagopalan@juno.com), 515 Basswood Drive ; # apt L-120, Nashville, TN 37209. *Shifts on product spaces E X F.* Preliminary report.

A shift operator on a Banch space E is a linear isometry T from E into E whose range is of codimension 1 and with O being the only element in the intersection of the ranges of all integral powers of T. If E , F are Banach spaces then the product space E X F is their product with sup norm.

It is known that if E is a Banach space with a shift then E X E also has a shift. The natural question is what happens if E is not isometric with F ? It was generally conjuctured that in that case there will be no shift on E X F.

Here we give an example of spaces E , F (not isometric) with shifts and so that E X F has a shift. (Received August 25, 2008)

1046-46-370 **Weihua Li***, Department of Mathematics and Statistics, Kingsbury Hall, Durham, NH 03824, and **Don Hadwin**. *A Modified Version of Free Orbit-Dimension of von Neumann Algebras.*

Based on the notion of free orbit-dimension introduced by D. Hadwin and J. Shen, we introduce a new invariant on finite von Neumann algebras that do not necessarily act on separable Hilbert space. We show that this invariant is independent on the generating set, and we extend some results in the paper of D. Hadwin and J. Shen to von Neumann algebras that are not finitely generated. (Received August 28, 2008)

1046-46-437 **Woodford W. Zachary*** (wwzachary@earthlink.net), Department of Electrical and Computer Eng., Howard University, Washington, DC 20059, and **Tepper L. Gill** (tgill@access4less.net), Department of Electrical and Computer Eng., Howard University, Washington, DC 20059. *Constructive Representation of the Feynman Operator Calculus in Banach Spaces.*

A new class of separable Banach spaces is first constructed which contain the Henstock-Kurzweil and Denjoy-Perron integrable functions as well as the class of finitely additive set functions (in particular, the Feynman kernel and the Dirac measure) as norm bounded elements. Then infinite tensor product Banach spaces are constructed along the lines used by von Neumann to construct infinite tensor product Hilbert spaces. These spaces are used to extend our earlier constructive representation theory for the Feynman operator calculus in Hilbert spaces to the Banach space setting. It is then shown that the usual theory of semigroups on Banach spaces can be extended to the time-ordered setting. This means that the formulation of physical theories using our approach is a natural extension of basic operator theory to the time-ordered setting. It also means that the problematic disentanglement method used by Feynman to justify his theory by relating it to standard methods is not required when our approach is used. Finally,the Feynman path integral is extended to a very general setting and a generalized Feynman-Kac theorem is discussed which is applicable to parabolic, hyperbolic and Schroedinger equations. (Received September 02, 2008)

1046-46-442 **M. D. Voisei*** (mvoisei@towson.edu), Towson University, Department of Mathematics, 7800 York Rd, Room 316, Towson, MD 21252. *Representability of Monotone Operators.*

For a monotone operator in a non-reflexive Banach space settings various notions of representability are introduced and compared to one another while the universality of these representations with respect to maximality as well as the current progress on the Rockafellar Conjecture are discussed. (Received September 03, 2008)

1046-46-467 **Geoffrey L Price*** (glp@usna.edu), Department of Mathematics 9E, United States Naval Academy, 572C Holloway Road, Annapolis, MD 21402. *Binary shifts of higher commutant index.* Preliminary report.

It has been known for some time that all binary shifts on the hyperfinite II_1 factor of commutant index 2 are cocycle conjugate. We discuss what is known about binary shifts of higher commutant index. There are, for example, at least 2 and at most finitely many cocycle conjugate classes of binary shifts of commutant index 3. (Received September 04, 2008)

1046-46-468 **Naoto Kumano-go*** (ft24343@ns.kogakuin.ac.jp), Kogakuin University, 1-24-2 Nishishinjuku, Shinjuku-ku, Tokyo, 163-8677, Japan. *Phase space Feynman path integrals via piecewise bicharacteristic paths and their semiclassical approximations.*

We give a fairly general class of functionals for which the phase space Feynman path integrals have a mathematically rigorous meaning. More precisely, for any functional belonging to our class, the time slicing approximation of the phase space path integral converges uniformly on compact subsets of the phase space. Our class of functionals is rich because it is closed under addition and multiplication. The interchange of the order with the Riemann integrals, the interchange of the order with a limit and the perturbation expansion formula hold in the phase space path integrals. The use of piecewise bicharacteristic paths naturally leads us to the semiclassical approximation on the phase space.

Reference: N. Kumano-go and D. Fujiwara, Phase space Feynman path integrals via piecewise bicharacteristic paths and their semiclassical approximations, Bull. Sci. Math. 132 (2008) 313-357. (Received September 04, 2008)

1046-46-492 **Mikhail I Ostrovskii*** (ostrovsm@stjohns.edu), Department of Mathematics, St. John's University, 8000 Utopia Parkway, Queens, NY 11439. *Auerbach bases and minimal-volume sufficient enlargements for normed spaces.* Preliminary report.

A symmetric, bounded, closed, convex set A in a finite dimensional normed space X is called a *sufficient enlargement* (SE) for X (or of the unit ball B_X) if, for an arbitrary isometric embedding of X into a Banach space Y, there exists a projection $P : Y \to X$ such that $P(B_Y) \subset A$. A sufficient enlargement A for X is called a *minimal-volume sufficient enlargement* (MVSE) if vol$A \leq$ vol$D$ for each SE D for X. Possible shapes of MVSE were recently characterized by the author [J. Funct. Anal., **255** (2008), no. 3, 589–619] in terms of zonotopes generated by totally unimodular matrices. In the mentioned paper it was also proved that spaces X having a non-parallelepipedal MVSE are rather special: they should have a two-dimensional subspace whose unit ball is linearly equivalent to a regular hexagon. On the other hand, easy examples show that the presence of the regular hexagonal section of B_X does not imply that X has a non-parallelepipedal MVSE.

In this talk the author will present a characterization of finite-dimensional normed spaces having non-parallelepipedal MVSE in terms of Auerbach bases. (Received September 04, 2008)

1046-46-599 **Kevin James Beanland*** (kbeanland@vcu.edu), 1930 Floyd Avenue, Richmond, VA 23220, and **Spiros Argyros** and **Haris Raikoftsalis**. *A Weak Hilbert Space not Isomorphic its Subspaces.*

In recent work with Spiros Argyros and Haris Raikoftsalis we constructed a weak Hilbert Banach space on which every operator is can be decompoaed as a diagonal operator plus a strictly singular operator. The space also has the property that every block subspace is not isomorphic to any of it subspaces. We will briefly discuss the construction. (Received September 08, 2008)

1046-46-782 **Gerald W. Johnson*** (gjohnson2@math.unl.edu), gjohnson2@math.unl.edu, Lincoln, Nebraska685, 68588-0130. *Disentangling in Feynman's operation calculi for non-commuting operators Disentangling in Feynman's operational calculi for Disentangling in Feynman's operational calculi for non-commuting operators.*

'Disentangling' is the central operation of Feynman's operational calculi for non-commuting operators. The point of this operation is to arrange the sums of products of the non-commuting operators in the 'right' way as governed by measures attached to the operators. Such calculations are often difficult to do. We will give, as time permits, some relatively simple examples where the disentangling can be carried out at least partially.Johnson (Received September 11, 2008)

1046-46-835 **Anna Kamińska** and **Anca M. Parrish*** (abuican1@memphis.edu), 1055 Goodman St, Memphis, TN 38111. *Smooth and extreme points in Marcinkiewicz function spaces.*

The Marcinkiewicz function spaces M_W generated by a decreasing weight $w : \mathbb{R}_+ \to \mathbb{R}_+$ are the spaces of measurable functions f satisfying $\|f\|_W = \sup_{t>0} \frac{\int_0^t f^*}{W(t)} < \infty$, where f^* is the decreasing rearrangement of f and $W(t) = \int_0^t w$. We also define $M_W^0 = \left\{ f \in M_W : \lim_{t \to 0^+, \infty} \frac{\int_0^t f^*}{W(t)} = 0 \right\}$. M_W^0 is the subspace of all order continuous elements of M_W. The dual of M_W^0 is the Lorentz space $\Lambda_{1,w}$ with the norm $\|f\|_{1,w} = \int_0^\infty f^* w$. Theorem: Let $f \in S_{M_W}$ (or $f \in S_{M_W^0}$). Then f is a smooth point in M_W (or M_W^0) if and only if there exists a unique $0 < a < \infty$ such that

$$1 = \|f\|_W = \frac{\int_0^a f^*}{W(a)}.$$

Theorem: A function $f \in S_{M_W}$ is an extreme point if and only if $f^* = w$. M_W^0 does not have any extreme points. (Received September 11, 2008)

1046-46-1140 **Alberto A. Condori*** (condoria@msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824. *On the sum of superoptimal singular values.* Preliminary report.

We discuss the following extremal problem and its relevance to the sum of the so-called superoptimal singular values of a matrix function: Given an $m \times n$ matrix function Φ on the unit circle T, when is there a matrix function Ψ_* in the set $A_k^{n,m}$ such that

$$\int_T \mathrm{trace}(\Phi(\zeta)\Psi_*(\zeta))dm(\zeta) = \sup_{\Psi \in A_k^{n,m}} \left| \int_T \mathrm{trace}(\Phi(\zeta)\Psi(\zeta))dm(\zeta) \right| ?$$

The set $A_k^{n,m}$ is defined by

$$A_k^{n,m} = \left\{ \Psi \in H_0^1 : \|\Psi\|_{L^1} \le 1, \mathrm{rank}\Psi(\zeta) \le k \text{ a.e. } \zeta \in T \right\}.$$

We introduce Hankel-type operators on spaces of matrix functions and prove that this problem has a solution if and only if the corresponding Hankel-type operator has a maximizing vector. We also characterize the smallest number k for which

$$\int_T \mathrm{trace}(\Phi(\zeta)\Psi(\zeta))dm(\zeta)$$

equals the sum of all the superoptimal singular values of an admissible matrix function Φ for some $\Psi \in A_k^{n,m}$. Moreover, we provide a representation of any such function Ψ when Φ is an admissible very badly approximable unitary-valued $n \times n$ matrix function. (Received September 14, 2008)

1046-46-1280 **Alan D Wiggins*** (alan.d.wiggins@vanderbilt.edu), Department of Mathematics, 1326 Stevenson Center, Vanderbilt University, Nashville, TN 37240. *Normalizers of Subalgebras of II_1 Factors.*

Given a subalgebra B of a II_1 factor M, define the groupoid normalizers $\mathcal{GN}(B)$ of B in M as all partial isometries $v \in M$ such that $vBv^*, v^*Bv \subseteq B$. We show that when $B_i' \cap M_i = \mathcal{Z}(B_i)$, $i = 1, 2$, then

$$\mathcal{GN}(B_1)'' \overline{\otimes} \mathcal{GN}(B_2)'' = \mathcal{GN}(B_1 \overline{\otimes} B_2)''$$

This is joint work with Roger Smith, Stuart White, and Junsheng Fang. (Received September 15, 2008)

1046-46-1364 **Michelle R Craddock*** (craddockmichelle@aol.com). *Geometric Properties inherited by Ordered Tensor Products.* Preliminary report.

Grothendieck's Résumé and Memoir opened many directions and questions in functional analysis. One of them is what geometric properties can be inherited from Banach spaces X and Y to their projective tensor product $X \hat{\otimes}_\pi Y$ and to their injective tensor product $X \check{\otimes}_\varepsilon Y$. I have shown that reflexivity and the Grothendieck space property are inherited from ℓ_p $(1 < p < \infty)$ and any Banach lattice X to their Fremlin projective tensor product

$\ell_p\hat{\otimes}_F X$ and to their Wittstock injective tensor product $\ell_p\tilde{\otimes}_i X$ under some circumstances. (Received September 15, 2008)

1046-46-1388 **Masayoshi Kaneda*** (mkaneda@math.uci.edu), Department of Mathematics, The University of Mississippi, University, MS 38677-1848. *Multipliers and Extreme Points of Operator Spaces.*

In the first part of the talk, we give an alternative definition of one-sided multipliers and quasi-multipliers of operator spaces. Then we characterize the operator algebras that have an (approximate) contractive (one-sided) identity in terms of quasi-multipliers and extreme points. We also give an operator space characterization of C*-algebras and their one-sided ideals. In the second part, we show that a ternary ring of operators with predual can be decomposed to the direct sum of a two-sided ideal, a left ideal, and a right ideal of some von Neumann algebra. Using this decomposition, we give a definition of two-sided multipliers of operator spaces which generalize two-sided multipliers of C*-algebras. (Received September 15, 2008)

1046-46-1433 **Tom Kriete**, **Barbara MacCluer** and **Jennifer Moorhouse*** (jmoorhouse@colgate.edu), Department of Mathematics, Colgate University, 13 Oak Drive, Hamilton, NY 13346. *Toeplitz-Composition Algebras with Several Generators.*

We consider those linear fractional maps of the unit disk having distinct points $\zeta, \eta \in \partial D$ with $\varphi(\zeta) = \eta$. For a finite set $\varphi_1, \varphi_2, ..., \varphi_n$, taken from this class, we generate the C^*-algebra $C^*(T_z, C_{\varphi_1}, C_{\varphi_2}, ..., C_{\varphi_n})$ of composition operators and Toeplitz operators on H^2. We give a concrete description of the Calkin algebra $C^*(T_z, C_{\varphi_1}, C_{\varphi_2}, ..., C_{\varphi_n})/\mathcal{K}$ and exhibit a short exact sequence

$$0 \to \mathcal{K} \to C^*(T_z, C_{\varphi_1}, C_{\varphi_2}, ..., C_{\varphi_n}) \to \mathcal{D} \to 0.$$

(Received September 15, 2008)

1046-46-1491 **Hermann Koenig** and **Nicole Tomczak-Jaegermann*** (nicole.tomczak@ualberta.ca), Dept. of Meth and Stat Sciences, University of Alberta, Edmonton, Alberta T6G 2G1, Canada. *Projecting l_∞ onto classical spaces.*

We describe an explicit construction of a linear projection of a symmetric conical section of the n-dimensional cube onto a $(1+\varepsilon)$ - isomorphic version of the Euclidean ball of proportional dimension, or more generally onto a $(1+\varepsilon)$ - isomorphic image of an l_p^m - ball. Allowing non-linear projections (of logarithmic polynomial nonlinearity) we may even project the full n-dimensional cube onto the same images. This is done by gluing together explicit projections onto two-dimensional spaces, interpreting and modifying a paper of Ben-Tal and Nemirowski. (Received September 15, 2008)

1046-46-1570 **Aderaw Workneh Fenta*** (aderaw.fenta@csm.astate.edu), Deaprtment of Mathematics & Statistics, Arkansas State University, P.O. Box 70, State University, AR 72467. *Lacunary Orbits for Multiplication operators in $C[0,1]$ and $L_p[0,1], 1 \le p < \infty$.*

We show that if $\{\lambda_k\}_{k=1}^\infty$ is a lacunary sequence and h is a function in $C[0,1]$ or $L_p[0,1], 1 \le p < \infty$ such that for some $\delta > 0$, $h \ne 0$ almost everywhere in the interior of the interval $(1-\delta, 1)$, then the lacunary orbit of h under the multiplication operator, namely the sequence $\{t^{\lambda_k} h(t)\}_{k=1}^\infty$ is a basic sequence.
(Received September 16, 2008)

1046-46-1611 **Genady Ya Grabarnik*** (genadyg@hotmail.com), IBM TJ Watson Reserach Center, Hawthorne, NY 10532, and **Larisa Shwartz**, IBM TJWatson Reserach, 19 Skyline dr, Hawthorne, NY 10532. *Non-Commutative majorant ergodic theorem for sub-sequences.*

The aim of the paper is to extend results of the Burgain about pointwise convergence of the non-standard ergodic averages (squares) to the case of automorphism of the Hilbert space with cone.

We establish a majorant theorem for the averages over squares. As a consequence of the theorem we show pointwise (or some variant of it) for the case of automorphism acting on von Neumann algebras, operator spaces, etc.

Goldstein, M.S.; Grabarnik, G.Ya., Almost Sure Convergence Theorems in von Neumann Algebras., Israel J. Math., V. 76, 1991, No. 1-2, pp. 161–182. (Received September 16, 2008)

1046-46-1678 **Alexandru Gabriel Atim*** (atimg@gwm.sc.edu), USC Lancaster, P O Box 889, Lancaster, SC 29721, and **Robert R Kallman**. *The Projective Unitary Group is Algebraically Determined Polish group.*

Let G be a Polish group. G is said to be an algebraically determined Polish group if for any Polish group H and algebraic isomorphism $\varphi : H \to G$ we have that φ is a topological isomorphism. Let H be a separable infinite dimensional complex Hilbert space. We will prove that the projective unitary group, the group of

$*$-automorphisms of $\mathcal{L}(\mathcal{H})$ and the complex isometry group of H are algebraically determined Polish groups. Similar results hold for their real Hilbert space analogues and for most (but not all) of the finite dimensional real and complex isometry groups. (Received September 16, 2008)

1046-46-1823 **Vladyslav Yaskin*** (vladyaskin@math.ualberta.ca), Department of Math. & Stat. Sciences, University of Alberta, Edmonton, Alberta T6G 2G1, Canada. *On embeddings of normed spaces in L_{-k}.*

The notion of embedding of a normed space in L_{-k} was introduced by A. Koldobsky. It is an open question whether a space $(\mathbb{R}^n, \|\cdot\|)$ that embeds in L_{-k} necessarily embeds in L_{-m} for $0 < k < m < n-3$. We solve a related problem. We show that there is a normed space $(\mathbb{R}^n, \|\cdot\|)$ that embeds in L_{-m} but not in L_{-k}. (Received September 16, 2008)

1046-46-1899 **M ZUHAIR NASHED*** (znashed@mail.ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816. *A Hierarchy of Differential Approximations for Nonsmooth Operators and Variational Problems.* Preliminary report.

Let X and Y be real normed spaces and F be a mapping from X into Y. We introduce a class of approximations to F(x+h)-F(x)in the form of a family L(x+h)h, where the family of bounded linear operators L(x+h) is uniformly bounded in the operator norm for h sufficiently small and the remainder R(x;h):= F(x+h)-F(x)- L(x+h)h is considered "infintesimal" or of order o(h) in a hierarchy of senses. The hierarchy includes (and is motivated by) the concept of slant differentiability introduced in the paper X.Chen,Z.Nashed, and L. Qi, Smoothing methods and semismooth methods for nondifferentiable operator equations, SIAM j. Numer. Anal. 38(2000), 1200-1216. Weaker and stronger notions of slant differentiability emerge in this setting that are useful for Newton-like methods for nonsmooth or ill-posed operator equations and nonsmooth mechanics. (Received September 16, 2008)

1046-46-1930 **Matthew Neal** (nealm@denison.edu), Denison University, Granville, OH 43023, and **Bernard Russo*** (brusso@math.uci.edu), University of California, Irvine, CA 92697-3875. *On projective rigidity of Banach spaces.*

A category is *projectively stable* if the idempotent morphisms preserve the class. Notable examples: [L^1-spaces, contractions] (Douglas 1965), [C*-algebras, completely positive maps] (Choi-Effros 1977), [JC*-triples, contractions] (Friedman-Russo 1985). A *JC*-triple* is a norm closed subspace of $B(H,K)$ which contains aa^*a whenever it contains a.

In the other direction, a category is *projectively rigid* if every sub-object of an object in the category is the image of that object by an idempotent morphism. Notable examples: [L^1-spaces, contractions] (Douglas 1965), [preduals of von Neumann algebras, contractions] (Kirchberg 1993), [preduals of ternary rings of operators, complete contractions] (Ng-Ozawa 2001).

THEOREM. The category [preduals of JC*-triples with no Hilbertian summands, contractions] is projectively rigid.

Since preduals of von Neumann algebras are non-commutative L^1-spaces, the theorem is a statement about non-associative L^1-spaces. (Received September 16, 2008)

1046-46-1988 **Frank Sanacory*** (sanacoryf@oldwestbury.edu), SUNY - College at Old Westbury, Department of Mathematics and CIS, P.O. Box 210, Old Westbury, NY 11568. *Partial unconditionality on a regular array in a Banach space.* Preliminary report.

e review several recent results in extending partial unconditionality of weakly null basic sequences in a Banach space (such as Schreier uncoditionality or Elton unconditionality) to a regular array. (Received September 16, 2008)

1046-46-2044 **Masayoshi Kaneda*** (mkaneda@math.uci.edu), Department of Mathematics, The University of Mississippi, University, MS 38677-1848. *Quasi-Multipliers and Algebrizations of Operator Spaces.*

One of the most interesting questions in the operator space theory was: What are the possible operator algebra products a given operator space can be equipped with? I answered the question by using quasi-multipliers. That is, a bilinear mapping on a given operator space is an operator algebra product if and only if the bilinear mapping is implemented by a contractive quasi-multiplier. Moreover, I gave an elegant metric (matrix norm) characterization of operator algebra products using the Haagerup tensor product. This is interesting because an algebraic structure (product) is induced by a geometric structure (matrix norm). This characterization also gives a short proof of the Blecher-Ruan-Sinclair Theorem as a simple corollary. If time permits, we discuss a characterization of operator algebras with a contractive approximate (one-sided) identity in terms of quasi-multipliers and extreme points. We also give an operator space characterization of C*-algebras and their one-sided ideals. (Received September 16, 2008)

1046-46-2083 **Patrizia Daniele*** (daniele@dmi.unict.it), Viale A. Doria, 6, 95125 Catania, Italy, and **Sofia Giuffre'** and **Antonino Maugeri**. *INFINITE DIMENSIONAL DUALITY AND APPLICATIONS TO EQUILIBRIUM PROBLEMS.* Preliminary report.

We present an infinite dimensional duality theory for optimization problems and evolutionary variational inequalities where the constraint sets are given by inequalities, namely $g(x) \in -C$, with C ordering cone, and also by equalities, namely $h(x) = \theta_Z$. We ensure the strong duality between such convex optimization problem and its Lagrange dual without assumptions on the interior of the ordering cone and apply our results to a wide class of dynamic equilibrium problems. (Received September 17, 2008)

47 ► Operator theory

1046-47-37 **Asuman G. Aksoy*** (aaksoy@cmc.edu), Department of Mathematics, Claremont McKenna College, Claremont, CA 91711. *Some Results in Metric Trees.*

The study of injective envelopes of metric spaces, also known as metric trees (R-trees or T-theory), has its motivation in many subdisciplines of mathematics as well as biology/medicine and computer science. Its relationship with biology and medicine stems from the construction of phylogenetic trees.Concepts of "string matching" in computer science is closely related with the structure of metric trees .A metric tree is a metric space (M, d) such that for every x, y in M there is a unique arc between x and y and this arc is isometric to an interval in $\mathbb{R}$. In this talk, we examine convexity and compact structures in metric trees and show that nonempty closed convex subsets of a metric tree enjoy many properties shared by convex subsets of Hilbert spaces. Furthermore, we show that a setvalued mapping T^* of a metric tree M with convex values has a selection $T : M \to M$ for which $d(T(x), T(y)) \leq d_H(T^*(x), T^*(y))$ for each $x, y \in M$. Here by d_H we mean the Hausdroff distance. We will mention some applications. (Received June 25, 2008)

1046-47-154 **Bernd Hofmann*** (hofmannb@mathematik.tu-chemnitz.de), Department of Mathematics, Chemnitz University of Technology, Reichenhainer Str. 39/41, D-09107 Chemnitz, Germany. *Convergence rates in regularization when the solutions are nonsmooth with respect to forward operators.*

We consider the method of approximate source conditions for obtaining convergence rates of regularized solutions to linear and nonlinear inverse and ill-posed problems with forward operators mapping between Hilbert or Banach spaces. For linear problems our focus is on general regularization schemes, whereas the focus is on Tikhonov regularization with convex but not necessarily smooth stabilizing functionals in the nonlinear case. Moreover, we outline the chances and limitations of the method in a nonlinear approach depending on structural conditions expressing the local character of nonlinearity in a neighbourhood of the true solution. Link conditions between the smoothness of the true solution and the smoothing properties of the forward operator are studied, where smoothness is considered in a very general sense. (Received August 07, 2008)

1046-47-207 **Carl C Cowen** (ccowen@iupui.edu) and **Gajath Gunatillake*** (mgunatillake@aus.edu), Department of mathematics and statistics, POBOX 26666, Sharjah, United Arab Emirates, and **Eungil Ko** (eiko@ewha.ac.kr). *Hermitian Weighted Composition Operators on Weighted Hardy Spaces.*

When f and φ are analytic on the unit disk and φ maps the unit disk to itself, the weighted composition operator $W_{f,\varphi}$ is defined by $W_{f,\varphi}(g) = f \cdot g \circ \varphi$ for g in an appropriate space. In this talk, we consider Hermitian weighted composition operators on weighted Hardy spaces, that is, on spaces of analytic functions on the disk for which the norm of $g(z) = \sum a_j z^j$ is given by $\|g\|^2 = \sum \beta(j)^2 |a_j|^2$ for a suitable weight sequence β.

In particular, necessary conditions will be provided for a weighted composition operator to be Hermitian on such spaces. On weighted Hardy spaces for which the kernel functions are $(1 - \overline{w}z)^{-n}$ for $n \geq 1$, such as the Hardy and the Bergman spaces, the two maps f and φ are explicitly identified. In the Bergman space, the spectral measures will also be computed. In the case when the spectral measure is continuous, the spectral subspaces turn out to be invariant subspaces for multiplication by z on the Bergman space and our results on Hermitian weighted composition operators can be used to compute the extremal functions for these subspaces. (Received August 19, 2008)

1046-47-229 **B. E. Rhoades*** (rhoades@indiana.edu), Department of Matheamtics, Indiana University, Bloomington, IN. *Fixed point iterations.* Preliminary report.

There are over 200 papers on fixed point iterations in the literature. I shall describe a few of the important ones, and critique some others. (Received August 25, 2008)

1046-47-241 **SHR-JING Chen*** (SHRCHEN2000@YAHOO.COM), Rutgers university, Piscataway, NJ 08901. *Vertex operator algebras and integrable system.*

In this paper, we first study classical integrable systems with properties including existence of Lax pairs, the reality property, and a construction of solutions using loop group actions (dressing actions). Then we construct a lower truncate module for the corresponding affine Lie algebra of level 0 from the dual space of functions on the solutions space of integrable system. Due to the existence of isotropy group on the solution space of classical integrable system , we then consider central extension of the full loop group action and construct highest weight module by applying formal uniformization theorem of Barron, Huang and Lepowsky [**?**]. we conculde with discussion on vertex operator algebra module and Miura transformation in quantized integrable system and compared classical and quantized integrable systems in terms of Lax form. (Received August 21, 2008)

1046-47-244 **Jonathan Henry Brown*** (jonathan.h.brown@dartmouth.edu), Department of Mathematics, 6188 Kemeny Hall, Dartmouth College, Hanover, NH 03755-3551. *Proper Actions of Groupoids on C^*-algebras.* Preliminary report.

In 1990 Rieffel introduced a notion of proper actions of groups on C^*-algebras. In his paper he shows how this generalizes the notion of a proper action of a group G on a space X, by considering the corresponding action of G on $C_0(X)$. Given a group G acting on a C^*-algebra A, Rieffel also introduces the notion of a generalized fixed point algebra $A^\alpha \subset M(A)$ and shows that A^α is Morita Equivalent to a subalgebra of the reduced crossed product. I will generalize these notions to groupoids acting on C^*-algebras and give a Morita Equivalence result. (Received August 22, 2008)

1046-47-336 **Mihai Popa*** (mipopa@indiana.edu), IU Bloomington, Rawles Hall 309, 831 E 3rd Street, Bloomington, IN 47405. *On the conditionally free analogue of the S-transform.*

Using the combinatorics of non-crossing partitions, we construct a conditionally free analogue of the Voiculescu's S-transform. The result is applied to analytical description of conditionally free multiplicative convolution and characterization of infinite divisibility. (Received August 26, 2008)

1046-47-462 **William M Higdon*** (whigdon@uindy.edu), Dept. of Mathematics and Computer Science, University of Indianapolis, 1400 E. Hanna Avenue, Indianapolis, IN 46227. *On The Numerical Range Of A Class Of Composition Operators on H^2.* Preliminary report.

The *numerical range* of an operator T on a Hilbert space H is the set $W(T) = \{< Tx, x >: \ \|x\| = 1\}$. Elementary properties of $W(T)$ include that it is convex and contains the eigenvalues and, more generally, its closure includes the spectrum of T. My work contributes towards the answer of a question posed by Professors Paul S. Bourdon and Joel H. Shapiro in their paper:"When Is Zero In The Numerical Range Of A Composition Operator?", Integral Equations and Operator Theory, 44 (2002), 410-441. The answer to the zero-inclusion question is, in general, unknown when the symbol of the composition operator is univalent, not linear fractional, and of parabolic nonautomorphism type. One characteristic of such mappings is that they have derivative equal to 1 at their boundary fixed point. A second characteristic they have, which makes the zero-inclusion question interesting and challenging, is that their induced linear model is of the plane translation case. A theorem of Professor Carl Cowen's answers the zero-inclusion question affirmatively when the symbol is in the half-plane translation case. I will discuss the zero-inclusion question for a class of composition operators in the unresolved case. (Received September 03, 2008)

1046-47-566 **Geoff R Goehle*** (goehle@dartmouth.edu), Department of Mathematics, Dartmouth College, 6188 Kemeny Hall, Hanover, NH 03755. *Group Bundle Duality.*

Given an abelian group bundle S with an open bundle map one can use operator algebras and universal constructions to define a dual group bundle. I will present a Pontryagin duality theorem which states that S is naturally isomorphic to its double dual. I will also describe how this theorem fits the themes of my current research. (Received September 08, 2008)

1046-47-567 **Robert F. Allen*** (rallen2@gmu.edu), George Mason University, Department of Mathematical Sciences, Fairfax, VA 22030. *Multiplication Operators on the Bloch Space of a Bounded Homogeneous Domain.* Preliminary report.

In this talk, we investigate the multiplication operators on the Bloch space of a bounded homogeneous domain. We characterize the bounded and compact operators, give norm estimates, and compute the spectrum. Lastly, we characterize the isometric operators on a large class of bounded symmetric domains. This is joint work with Flavia Colonna of George Mason University. (Received September 08, 2008)

1046-47-660 **Robert F. Allen** and **Flavia Colonna*** (fcolonna@gmu.edu), Dept. of Mathematical Sciences, George Mason University, 4400 University Drive, Fairfax, VA 22030. *Weighted composition operators on the Bloch space in $\mathbb{C}^n$.*

Let f be a complex-valued holomorphic function on a bounded homogeneous domain D in $\mathbb{C}^n$ containing the origin. For $z \in D$ define

$$Q_f(z) = \sup_{u \in \mathbb{C}^n \setminus \{0\}} \frac{|(\nabla f)(z)u|}{H_z(u, \overline{u})^{1/2}},$$

where ∇f is the gradient of f and H_z is the Bergman metric on D at z. The *Bloch space* of D is the Banach space $\mathcal{B}(D)$ of functions f such that $\beta_f = \sup_{z \in D} Q_f(z) < \infty$ with norm $\|f\|_{\mathcal{B}} = |f(0)| + \beta_f$. For $z \in D$, define

$$\omega(z) = \sup\{|f(z)| : f \in \mathcal{B}(D),\ \|f\|_{\mathcal{B}} \leq 1,\ f(0) = 0\}.$$

Let ψ be a holomorphic function on D and let φ be a holomorphic self-map of D. In this talk, we explore the role that the function ω plays in determining conditions that guarantee boundedness and compactness of the weighted composition operator $W_{\psi,\varphi} : f \mapsto \psi(f \circ \varphi)$ on $\mathcal{B}(D)$ and provide norm estimates. This is joint work with Robert F. Allen of George Mason University. (Received September 09, 2008)

1046-47-678 **Zeqing Liu*** (zeqingliu@dl.cn), Department of Mathematics, Liaoning Normal University, Dalian, Liaoning 116029, Peoples Rep of China. *The solvability of a new system of nonlinear variational-like inclusions.* Preliminary report.

In this paper, we introduce and study a new system of nonlinear variational-like inclusions involving $s-(G,\eta)-$maximal monotone operators, strongly monotone operators, cocoercive operators, relaxed monotone operators, and relaxed Lipschitz operators in Hilbert spaces. By using the resolvent operator technique associated with $s-(G,\eta)-$maximal monotone operators, we demonstrate the existence and uniqueness of solution for the system of nonlinear variational-like inclusions. (Received September 09, 2008)

1046-47-731 **Hakan Hedenmalm** (hakanh@math.kth.se), Department of Mathematics, KTH-Royal Institute of Technology, SE-100 44 Stockholm, Sweden, and **Alfonso Montes-Rodriguez*** (amontes@us.es), Departamento de Analisis Matematico, Universidad de Sevilla, aptdo 1160, 41013 Sevilla, Spain. *One to one compressions of composition operators and the Klein-Gordon equation.* Preliminary report.

In this talk, we will see how one-to-one compressions of composition operators on $L^1[-1,1]$ applies to show that the system

$$e^{\pi i\alpha nt}, \quad e^{i\pi\beta nt} \quad n = 0, 1, 2, \ldots,$$

where α and β are positive numbers, is weakly dense on $L^\infty(\mathbb{R})$ if and only if $\alpha\beta \leq 1$. This problem can be stated in terms of the solution of a version of the 1D Klein-Gordon equation. In fact, if a bounded Borel measure μ supported in a curve $\Gamma \subset \mathbb{C}$, which is absolutely continuous with respect to the arc length, and whose Fourier transform $\widehat{\mu}$ vanishes on a set $\Lambda \subset \mathbb{C}$, must be athomatically the zero measure, (Γ, Λ) is called a Heisemberg uniqueness pair. When Γ is the hyperbola $x_1x_2 = 1$, and Λ is the lattice-cross

$$\Lambda = (\alpha\mathbb{Z} \times \{0\}) \cup (\{0\} \times \beta\mathbb{Z}),$$

then (Γ, Λ) is Heisemberg uniqueness pair if and only if $\alpha\beta < 1$; in this situation $\widehat{\mu}$ solves the version of the Klein-Gordon equation. Some elements of ergodic theory, like the Birkhoff's ergodic theorem will also be needed. (Received September 10, 2008)

1046-47-846 **Dan D. Pascali*** (dp39@nyu.edu), 251 Mercer Street, New York, NY 10012-1185. *On the index solvability for variational inequalities with (S)-mappings.*

Recent investigations on the topological degree for (S)-mappings with maximal monotone perturbations allows us to introduce a related index of solvability. On the other hand, a variational inequality can be converted into a inclusion determined by a sum of a mapping of monotone type and a subdifferential. This talk enlarges the hypotheses which permit to derive the existence of solutions of variational inequalities when the corresponding index of solvability is different from zero. (Received September 12, 2008)

1046-47-884 **Stefan Richter*** (richter@math.utk.edu), Department of Mathematics, University of Tennessee, Knoxville, TN 37996, and **Carl Sundberg**. *Extremals for the families of commuting spherical contractions and their adjoints.* Preliminary report.

Let $d \geq 1$ and let $\mathcal{F}$ denote the family of all commuting spherical contractions, i.e. those commuting d-tuples $T = (T_1, .., T_d)$ of Hilbert space operators satisfying $\sum_{j=1}^{d} T_j^* T_j \leq I$. Then the family of adjoint tuples, $\mathcal{F}^*$, consists of the d-contractions. They satisfy $\| \sum_{j=1}^{d} T_j x_j \|^2 \leq \sum_{j=1}^{d} \|x_j\|^2$ for all $x_1, ..., x_d$ in the Hilbert space. An operator tuple S acting on $\mathcal{H}$ is called an extremal for a family $\mathcal{G}$, if and only if the only way to extend S to a tuple $T \in \mathcal{G}$ acting on $\mathcal{K} \supseteq \mathcal{H}$ is by taking direct sums. It is a theorem of Agler that every operator tuple in a family can be extended to an extremal.

We show that the extremals of the spherical contractions $\mathcal{F}$ are of the form $S^* \oplus U$, where S is the d-shift tuple acting on a Drury-Arveson space and U is a spherical unitary tuple. The resulting extension theorem had been known and is due to Mueller-Vasilescu and to Arveson.

It appears to be unknown what the extremals for the d-contractions $\mathcal{F}^*$ are. We characterize all extremals T of $\mathcal{F}^*$ which satisfy that the defect operator $I - \sum_{j=1}^{d} T_j T_j^*$ has rank zero or one. (Received September 12, 2008)

1046-47-914 **Nathan S. Feldman*** (feldmanN@wlu.edu), Mathematics Department, Washington & Lee University, Lexington, VA 24450. *Hypercyclic Operators with a Prescribed Spectrum.* Preliminary report.

A bounded linear operator on a Hilbert space is hypercyclic if it has a point with dense orbit. Herrero proved that if an operator is hypercyclic, then every component of its spectrum must intersect the unit circle. We will prove the converse. We will show that given any compact set K in the complex plane such that every component of K intersects the unit circle, there is a hypercyclic operator whose spectrum is equal to K. Thus Herrero's necessary condition is also sufficient in describing the spectra of hypercyclic operators. (Received September 12, 2008)

1046-47-922 **Mohammad Khadivi*** (mohammad.reza.khadivi@jsums.edu), Department of Mathematics, Jackson State University, Jackson, MS 39217, and **Mokhtar Aouina** (mokhtar.aouina@jsums.edu), Department of Mathematics, Jackson State University, Jackson, MS 39217. *Inequalities and Operator Means.*

The purpose of this talk is to revisit "Operator Means" and present new results as well as a conjecture. Several mathematicians such as W.L.Green, T. Morely, Anderson, and Trapp and many others have investigated the subjects to a satisfactory level.

Operator Means have played a pivotal role in applications such as "Infinite Electrical Networks", and "Shorted Operators". We will use range inclusion of operators and some aspects of spectral theory to retrieve some of the well known results about operator Means and derive some new ones. We state some of the works by William Green (2005), such as AGH (Arithmetic, Geometric, and Harmonic) inequality for operators. More specifically several theorems will be discussed and a new conjecture will be revealed. (Received September 12, 2008)

1046-47-985 **P. P. B. Eggermont*** (eggermon@udel.edu), Food and Resource Economics, University of Delaware, Newark, DE 19711, and **M. Z. Nashed**. *On weakly bounded noise in ill-posed, non-quadratic minimization problems.* Preliminary report.

We study nonlinear ill-posed operator equations with noisy data in Hilbert space. However, rather than assuming that the noise is small in the Hilbert space norm, we assume that the noise is small in the weak sense, and study what happens when the noise converges weakly to 0. This assumption is made quantitative by sending the noise through a certain compact operator and requiring a strong bound on the image.

The nonlinear ill-posed problem is formulated as a non-quadratic minimization problem in Hilbert space, with a Tikhonov-Phillips penalization added. Two typical cases are least-squares for a nonlinear operator equation, and non-quadratic functionals for linear ill-posed operator equations, such as occur in maximum penalized likelihood estimation.

We discuss convergence rates of the regularized minimizers when the non-quadratic minimization problem admits effective quadratic approximations. (Received September 13, 2008)

1046-47-1055 **Gabriel T Prajitura*** (gprajitu@brockport.edu), Department of Mathematics, SUNY Brockport, Brockport, NY 14420. *Irregularity of orbits of operators.* Preliminary report.

We will discuss iregularity of orbits, a property shared by two very different types of orbits: the dense ones(hypercyclic) and the rare one. (Received September 15, 2008)

1046-47-1170 **Trieu L. Le*** (t29le@math.uwaterloo.ca), Department of Pure Mathematics, University of Waterloo, 200 University Avenue West, Waterloo, Ontario N2L3G1, Canada. *A refined Luecking's theorem and finite-rank products of Toeplitz operators on the Bergman space.*

For any bounded function f on $\mathbb{D}$, let T_f denote the corresponding Toeplitz operator on the Bergman space $A^2(\mathbb{D})$. A recent result of D. Luecking shows that if T_f has finite rank then f must be the zero function. Using a refined version of this result, we show that if all, except possibly one, of the functions $f_1, \ldots, f_m$ are radial and $T_{f_1} \cdots T_{f_m}$ has finite rank, then one of these functions must be zero. (Received September 15, 2008)

1046-47-1190 **Marta Asaeda*** (marta@math.ucr.edu), Mathematics Department, UC Riverside, 900 Big Springs Dr, Riverside, CA 92521, and **Seidai Yasuda**. *Non-existence of certain finite depth subfactors.*

We prove that the graphs given in Haagerup's list are not principal graphs for subfactors except possibly three of them. We use techniques in classical algebraic number theory. (Received September 15, 2008)

1046-47-1313 **Jan Cameron***, Department of Mathematics, Mailstop 3368, Texas A&M University, College Station, TX 77843-3368. *Structure results for normalizers of* II_1 *factors.*

For an inclusion of II_1 factors $N \subset M$ we study the normalizer $\mathcal{N}_M(N) = \{u \in \mathcal{U}(M) : uNu^* = N\}$ and the von Neumann algebra it generates. We obtain a crossed product decomposition of the generated von Neumann algebra with respect to a countable discrete subgroup of $\mathcal{N}_M(N)$. By analyzing the structure of certain weakly closed modules in $\mathcal{N}_M(N)''$, this leads to a "Galois-type" theorem for normalizers, in which we find a description of intermediate subalgebras of $\mathcal{N}_M(N)''$ in terms of a unique countable subgroup of the normalizing group. Implications for inclusions $N \subset M$ arising from the crossed product, group von Neumann algebra, and tensor product constructions are also addressed. Our work leads to a construction of new examples of norming subalgebras of II_1 factors: If $N \subseteq M$ is a regular inclusion of II_1 factors, then N norms M. (Received September 15, 2008)

1046-47-1448 **Gregory Adams** and **George R Exner*** (exner@bucknell.edu), Department of Mathematics, Bucknell University, Lewisburg, PA 17837. *n-contractivity and k-hyponormality of some Bergman-like weighted shifts.* Preliminary report.

The classes of k-hyponormal operators on Hilbert space, $k = 1, 2, \ldots$, arise naturally from the Bram-Halmos characterization of subnormality. Similarly, the classes of n-contractive operators, $n = 1, 2, \ldots$, arise from the Agler-Embry characterization of a contractive subnormal operator. It is known that if a contraction is k-hyponormal it is $2k$-contractive. We provide examples of perturbations of Bergman-type weighted shifts for which an order k^2-contractivity implies (in fact, is equivalent to) k-hyponormality. The primary technique is the use of orthogonal polynomials to facilitate a determinant computation. (Received September 15, 2008)

1046-47-1577 **Pekka J. Nieminen*** (pjniemin@cc.helsinki.fi), Department of Mathematics and Statistics, University of Helsinki, PO Box 68, 00014 Helsinki, Finland. *Compact approximation of integral operators with applications to composition operators.*

It is known that every linear operator acting between L^1 spaces of compact metric measure spaces can be represented as an integral operator with respect to a stochastic kernel. In 1984 Lutz Weis showed how this representation can be used to construct a best weakly compact approximation for the operator.

We provide a modification of Weis's method and seek conditions under which it yields a best compact approximation. As applications we derive formulas for the essential and weak essential norms of (weighted) analytic composition operators and their differences. (Received September 16, 2008)

1046-47-1643 **Jens Gerlach Christensen***, 329 Lockett Hall, Louisiana State University, Baton Rouge, LA 70803. *Uncertainty Principles from Representations of Lie Groups.*

First we present a general uncertainty principle for the infinitesimal operators obtained from a representation of a Lie group. Next we apply this to a representation of the Euclidean motion group to obtain an uncertainty principle on the sphere. (Received September 16, 2008)

1046-47-1753 **Manuel Ponce-Escudero*** (mpe@us.es), C/ Virgen del Buen Suceso, 3, 41620 Marchena, Sevilla, Spain, and **Alfonso Montes-Rodríguez** and **Stanislav Shkarin**. *Invariant Subspaces and Composition Operators.*

A vector subspace of a Hilbert space is said *invariant* under a given operator T in case T maps it into itself. The set of all subspaces invariant under T is called the *lattice of invariant subspaces* of T.

In this talk we will study the lattice of invariant subspaces of a class of composition operators acting on several weighted Bergman spaces (including the classical Hardy and Bergman spaces). The characterization is

completed establishing explicit isomorphisms between these spaces and certain weighted Sobolev spaces. (Received September 16, 2008)

1046-47-1763 **Richard D. Burstein*** (rburstei@uottawa.ca), Department of Mathematics and Statistics, University of Ottawa, 585 King Edward Avenue, Ottawa, Ontario K1N 6N5, Canada. *Automorphisms of planar algebras.* Preliminary report.

Starting with a subfactor planar algebra, a subfactor may be constructed which has precisely that planar algebra as its standard invariant. Any sufficiently small planar subalgebra of a bipartite graph planar algebra is a subfactor planar algebra. Since the action of the planar operad on bipartite graph planar algebras is relatively simple, finding such a planar subalgebra allows a precise description of the standard invariant of the corresponding subfactor.

An invertible linear map on a planar algebra which commutes with the planar operad is an automorphism of the planar algebra. The fixed points of a group of such planar automorphisms are closed under the planar operad, and therefore constitute a planar subalgebra. A sufficiently large group acting on a bipartite graph planar algebra may have a subfactor planar algebra for its fixed points.

I will discuss several examples of this construction. Subfactor planar algebras which may produced in this way include those for all diagonal subfactors and Jones-Wassermann subfactors, as well as some examples of Bisch-Haagerup subfactors. The resulting classification of the planar algebras of diagonal subfactors provides many examples of non-isomorphic subfactors with the same standard invariant. (Received September 16, 2008)

1046-47-1917 **Mohan Ravichandran*** (mohanr@unh.edu), 16 Nichols Avenue, Newmarket, NH 03857. *Generalizations of Triangular Algebras.*

Given a Von Neumann algebra $\mathfrak{M} \subseteq B(H)$, a Kadison-Singer or KS algebra $\mathfrak{A}$ is a maximal reflexive algebra with diagonal $\mathfrak{M}$, ie, $\mathfrak{A}^* \cap \mathfrak{A} = \mathfrak{M}$. KS algebras can be viewed as generalizations of triangular operator algebras, which were introduced by Kadison and Singer in 1959 and have a long and rich history. In this talk, we construct several KS algebras, including ones with diagonal the hyperfinite and free group factors and indicate a standard way of getting new ones from old.

We characterize the radical of a KS algebra and construct KS algebras that are simple and in particular, do not contain any compact operators. We then analyze automorphisms of KS algebras and show that they need not be given by similarities. We then indicate applications of KS algebras to questions in the theory of non-selfadjoint operator algebras, like the transitive algebra question as well as problems in the self-adjoint theory, like the isomorphism problem for free group factors.

We conclude by making a case that the theory of KS algebras with diagonal type II(resp. type III) ought to be considered as type II(type III) non-selfadjoint theory, parallel to the Murray Von Neumann theory for Von Neumann algebras. (Received September 16, 2008)

1046-47-2043 **Shamindra Kumar Ghosh*** (shamindra.k.ghosh@vanderbilt.edu), 2000 24th Avenue South, Apartment G48, Nashville, TN 37212. *Planar algebra of group-type subfactors.*

We describe the planar algebra of: (i) the *Bisch-Haagerup subfactors*, namely, $P^H \subset P \rtimes K$ where two finite groups H and K act outerly on a II_1-factor P, (ii) given a finite set $\{\theta_i\}_{i \in I}$ of automorphisms of a II_1 factor N, the *diagonal subfactor* $N \subset M_I(N)$ where an element $x \in N$ sits in $M_I(N)$ diagonally with the i-th diagonal element being given by $\theta_i(x)$. Several correspondences between properties of the group and that of subfactors, namely, strong amenability, amenability and property (T) were derived for both cases. The planar algebra heavily depends on the cocycle obstruction to lifting the subgroup G in $Out(P)$ (resp., $Out(N)$) generated by H and K in case (i) (resp., θ_i in $Out(N)$ in case (ii)). In case (i), if we assume that the group generated by H and K in $Aut(P)$ intersects trivially with $Inn(P)$, (equivalently, the obstruction is trivial), then the planar algebra has an interesting similarity with IRF models in Statistical Mechanics. In cae (ii), when the obstruction is trivial, this planar algebra matches with Jones's example of planar algebra associated to finitely generated group. This is a joint work with Dietmar Bisch and Paramita Das. (Received September 16, 2008)

49 ► Calculus of variations and optimal control; optimization

1046-49-35 **Boris Mordukhovich** and **Nguyen Mau Nam*** (nguyenmn@utpa.edu), Department of Mathematics, 1201 W. University Dr., Edinburg, TX 78539. *Subgradients of Marginal Functions in Parametric Optimization.*

Marginal/value functions play a significant role in optimization and control theory. Because of their intrinsic nonsmooth feature, appropriate tools of generalized differentiation are required for the study of this class of functions and for their applications. In this talk we derive new results for computing and estimating subgradients of marginal functions in Banach spaces and specify these results for important classes of problems in parametric optimization with smooth and nonsmooth data. The results obtained allow us to establish new calculus rules of generalized differentiation as well as verifiable conditions ensuring robust stability in optimization problems. (Received June 22, 2008)

1046-49-51 **Mordukhovich Boris**, 656 W. Kirby, Detroit, MI 48202, and **Nguyen Mau Nam*** (nguyenmn@utpa.edu), 1201 W. University Dr., Edinburg, TX 78539. *Nonsmooth Analysis in Infinite Dimensions with Applications to Stability of Variational Systems.*

Differential calculus contains important mathematical tools used broadly in science and technology. However, major disadvantages of the classical differential calculus include the requirement on the differentiability of the initial data, while nonsmooth structures appear frequently and naturally in many mathematical and applied models. *Nonsmooth Analysis* refers to the study of generalized differential properties of sets, functions, and set-valued mappings with no differentiability requirements. In this talk we discuss new developments in nonsmooth analysis based on generalized differentiation of nonsmooth functions and mappings and then present a number of significant applications to sensitivity and Lipschitzian stability issues for constraint and variational systems. (Received July 12, 2008)

1046-49-96 **Marian Bocea*** (marian.bocea@ndsu.edu), Department of Mathematics, 300 Minard Hall, North Dakota State University, Fargo, ND 58105. *Variational characterizations of the yield set of a polycrystal: some model cases.*

New variational characterizations of the yield set of a polycrystal are presented in several model cases. The results are consequences of an asymptotic analysis of power-law functionals via Γ-convergence. (Received July 22, 2008)

1046-49-98 **Cristina Popovici*** (cristina.popovici@ndsu.edu), Department of Mathematics, 300 Minard Hall, North Dakota State University, Fargo, ND 58105. *The derivation of a heterogeneous plate theory from nonlinear elasticity.*

The effective elastic energy of a heterogeneous plate is obtained from three-dimensional nonlinear elasticity via De Giorgi's Γ-convergence. (Received July 22, 2008)

1046-49-458 **Qin Zhang*** (qzhang5@ncsu.edu), Department of Mathematics, Box 8205, North Carolina State University, Raleigh, NC 27695, and **Kazufumi Ito** (kito@math.ncsu.edu), Department of Mathematics, Box 8205, North Carolina State University, Raleigh, NC 27695. *A Nonsmooth Feedback Solution for a Class of Quantum Control Problems.*

We consider the optimal control problem of the quantum systems described by the Schrödinger equation. Control inputs enter through coupling operators and results in a bilinear control system. Nonsmooth feedback control laws are developed for the orbit tracking via a controlled Hamiltonian. Wellposeness and asymptotic tracking properties of the feedback laws are analyzed. Numerical integrations via time-splitting are also analyzed and used to demonstrate the feasibility of the proposed feedback laws. Next, a monotone scheme for the solving the optimality system is described. Finally, we develope the receding horizon control synthesis, which improves the performance of the proposed feedback laws significantly. (Received September 03, 2008)

1046-49-683 **Jesus A. Pascal*** (pascal@math.lsu.edu), 5727 NW, 7th Street, Suite 313, Miami, FL 33126. *Finding Explicitely the Value Function for an Optimal Control Problem.*

A one dimensional infinite horizon optimal control problem is considered, and using the dynamic programming approach we find explicitely the value function. (Received September 10, 2008)

1046-49-689 **Alec N. Kercheval*** (kercheva@math.fsu.edu), Department of Mathematics, 1017 Academic Way, Room 208, Florida State University, Tallahassee, FL 32306-4510, and **Juan F. Moreno**. *Optimal impulse control in currency markets when interventions affect rates.*

We address the problem of optimal Central Bank intervention in the exchange rate market when interventions create feedback in the rate dynamics. In particular, we extend the work done on optimal impulse control by Cadenillas and Zapatero (1999, 2000) to incorporate temporary market reactions to Bank interventions. The duration and level of these reactions can be random. We obtain new explicit optimal impulse control strategies that account for these market reactions. (Received September 10, 2008)

1046-49-791 **Ram. U. Verma*** (verma99@msn.com), 12085 Lake Cypress Circle, Suite I109, Orlando, FL 32828. *Hybrid Over-Relaxed Proximal Point Procedure and Generalized Yosida Regularization for First-Order Evolution Inclusions.*

First, a hybrid over-relaxed proximal point algorithm based on the operator variational convergence in the context of approximating solutions of a general class of inclusion problems is introduced. Then the generalized Yosida regularization using the theory of nonlinear semigroups is applied to first-order evolution inclusions in Hilbert space as well as in Banach space settings. The generalized Yosida regularization is not limited to just first-order evolution inclusions, but it encompasses other types of differential inclusions and beyond. (Received September 11, 2008)

1046-49-1066 **Akhtar A. Khan*** (aaksma@rit.edu), School of Mathematical Sciences, Rochester Institute of Technology, 85 Lomb Memorial Drive, Rochester, NY 14623, and **Baasansuren Jadamba** (bxjsma@rit.edu), School of Mathematical Sciences, Rochester Institute of Technology, 85 Lomb Memorial Drive, Rochester, NY 14623. *Regularization of Quasi Variationaal Inequalities.*

This talk will focus on regularization issues for quasi-variational inequalities. An ill-posed quasi-variational inequality with multi-valued maps can be conveniently formulated as a parameter identification problem on the graph of a variational selection. Using elliptic regularization for parametric variational inequalities, it is possible to pose another parameter identification problem that gives a stable approximation procedure for the ill-posed problem. The results discussed in this talk are quite general and are applicable to ill-posed variational inequalities, inverse problems, split-feasibility problem, among others. (Received September 14, 2008)

1046-49-1182 **Otmar Scherzer*** (otmar.scherzer@uibk.ac.at), Institute of Mathematics, Technikerstr. 21A, 6020 Innsbruck, Austria. *Sparse Regularization with l-q Penalty Term.*

We consider the stable approximation of sparse solutions to non-linear operator equations by means of Tikhonov regularization with a subquadratic penalty term. Imposing certain assumptions, which for a linear operator are equivalent to the standard range condition, we derive the usual convergence rate $O(\sqrt{\delta})$ of the regularized solutions in dependence of the noise level δ. Particular emphasis lies on the case, where the true solution is known to have a sparse representation in a given basis. In this case, if the differential of the operator satisfies a certain injectivity condition, we can show that the actual convergence rate improves up to $O(\delta)$.

This is joint work with M. Grasmair and M. Haltmeier (Received September 15, 2008)

1046-49-1228 **Stephen G Nash*** (snash@gmu.edu), Systems Eng. & Operations Research Dept., Mailstop 4A6, Fairfax, VA 22030. *Computational Optimization: Insights & Questions.*

We all want to do better, so it is natural to want to optimize. But it isn't always easy. Complex science and engineering problems lead to complex mathematical models and complex computations. Adding optimization on top of all this magnifies the difficulties. Success may require a combination of mathematical analysis, algorithmic development, sophisticated software, and practical insight. I will illustrate these challenges through some practical examples, and describe current approaches and areas of research. In addition, I will mention some longer-term questions about where computational optimization might be headed, and some ambitious goals that might offer inspiration. (Received September 15, 2008)

1046-49-1505 **Xin Guo*** (xinguo@newton.berkeley.edu), 4173 Etcheverry Hall, Dept of IEOR, UC Berkeley, Berkeley, CA 94720-1777, and **Guoliang Wu**. *Smooth Fit Principle for Impulse Control of Multi-dimensional Diffusion Processes.*

Value functions of impulse control problems are known to satisfy Quasi-Variational Inequalities (QVI) (Bensoussan and Lions (1982)). This paper proves the smooth-fit C^1 property of the value function for multi-dimensional controlled diffusions, using a viscosity solution approach. We show by examples how to exploit this regularity property to derive explicitly optimal policy and value function. (Received September 15, 2008)

1046-49-1923 **Denis Ridzal*** (dridzal@sandia.gov), Sandia National Laboratories, Optimization and UQ, P.O. Box 5800, MS 1320, Albuquerque, NM 87185, and **Pavel Bochev**, Sandia National Laboratories, Applied Mathematics and Applications, P.O. Box 5800, MS 1320, Albuquerque, NM 87185. *Scalable Solution Methods via Optimal Control Reformulation.*

We consider an optimization–based approach for the scalable solution of PDE problems comprised of multiple physics operators with fundamentally different mathematical properties. The approach relies on ideas from optimization and control to transform the solution of the composite multiphysics problem into the solution of a sequence of problems governed by scalable components.

The proposed optimization–based framework relies on three essential steps. First, an operator decomposition is applied to the original composite problem, breaking it down into components for which scalable solvers are available. Second, the components are coupled via distributed control parameters, used e.g. in the case of single–domain problems, and/or boundary control parameters, used e.g. in the context of multidomain problems, and a suitable objective functional. Third, the resulting large–scale PDE–constrained optimization problem is solved either directly as a fully coupled algebraic system, or in the null space of the PDE constraints.

We demonstrate the potential of our approach by devising a scalable linear solver for nearly hyperbolic PDEs, which relies solely on the solution of diffusion–dominated problems using algebraic multigrid techniques. Numerical results will be presented. (Received September 16, 2008)

1046-49-2017 **S K Mishra** (shashikant.dr@gmail.com), Department of Mathematics, Banaras Hindu University, Varanasi, UP 221005, India, **R N Mohapatra*** (ramm@mail.ucf.edu), 4000 Central Florida Blvd., Department of Mathematics, Orlando, FL 32816, and **Vinay Singh** (vinaybhu1981@gmail.com), Department of Mathematics, Banaras Hindu University, Varanasi, UP 221005, India. *Optimality Conditions and Efficiency in solving nonsmooth multiobjective programming problems.*

In this paper we establish a characterization for efficient solutions of nonsmooth multiobjective programming problems which generalize the results of Arana-Jimenez et al (Nonlinear Analysis 68 (2008) 24-34. We discuss results dealing with different types of functions of interest. (Received September 16, 2008)

1046-49-2063 **Anna S Bulanova*** (ftasb1@uaf.edu), PO Box 752592, Fairbanks, AK 99775, and **Sergei A Avdonin** and **Dmitri A Ovsyannikov**. *Optimal quadrature formulae related to solutions of initial boundary value problems.*

We present an approach to the construction of optimal quadrature formulae for classes of solutions of certain initial boundary value problems. Problems of maximization of an error functional over the set of integrands and optimization of quadrature weights for fixed nodes are considered. In cases when the set of integrands consists of solutions of an initial boundary value problem, optimal quadrature problems can be approached as problems of optimal control for partial differential equations. Several examples of parabolic initial boundary value problems are considered. We obtain estimates for an error in quadrature formulae and an optimality condition for quadrature weights. (Received September 17, 2008)

1046-49-2099 **Qingxia Li*** (qingxia@math.lsu.edu), Deapartment of Mathematics, Louisiana State University, Baton Rouge, LA 70803, and **Peter Wolenski** (wolenski@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Multiobjective optimization and nonlinear programming.*

In this paper, first we derive necessary conditions with the equality constraints subject to any cone by introducing value functions. We also derive necessary and sufficient conditions to a maximum function constrained by inequalities involving differentiable functions through a saddle value function with the aid of the Lagrangian multipliers. A concrete example is also given to display Tanino's results with his concept of subgradients to multiobjective functions. (Received September 17, 2008)

1046-49-2103 **Lingyan Huang*** (lingyan@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Convexity in Hamilton-Jacobi theory with measurable dependent time.*

In this paper, we consider a value function propagated from an initial cost and constraints by way of a differential inclusion through a Lagrangian with measurable time dependence. We show these value functions satisfy a subgradient form of the Hamilton-Jacobi equation with the aid of essential values. (Received September 17, 2008)

51 ► Geometry

1046-51-34 **Maryam Mirzakhani*** (mmirzakh@math.princeton.edu), Princeton University, Fine Hall, 904, Washington Road, Princeton, NJ 08544. *Geometry of surfaces, laminations, and dynamics over the moduli of Riemann surfaces.*

The moduli space of Riemann surfaces plays an important role in different branches of mathematics. In this talk we will discuss some geometric properties of these moduli spaces, and explain their relationship with Thurston's space of measured laminations. We will discuss some applications and related open problems motivated by the analogy between the moduli space of surfaces and homogeneous spaces of Lie groups. (Received June 19, 2008)

1046-51-188 **Kasra Rafi*** (kasra.rafi@gmail.com), Department of Mathematics, University of Oklahoma, Norman, OK 73019-031, and **Moon Duchin** and **Christopher Leininger**. *A compactification for the space of singular Euclidean metrics on a surface.*

Let F(S) be the space of singular Euclidean metrics of area one on a surface S. We provide an embedding of F(S) into the space of geodesic currents on S. This is similar to Bonahon's embedding of Teichmuller space into the space of geodesic currents; the length of a closed curve in a given singular flat metric is equal to the intersection number of this curve with the corresponding geodesic current. The closure of the image of this embedding is a compact set. We also give a description of the boundary at infinity. (Joint work with Moon Duchin and Chris Leininger.) (Received August 14, 2008)

1046-51-231 **Sreekrishna Palaparthi*** (sp49@buffalo.edu), 244 Mathematics Building, University at Buffalo, Buffalo, NY 14260. *Upper bound for the length of an n^{th}-shortest closed geodesic in a hyperbolic knot complement in S^3.*

The length of a shortest closed geodesic in a finite volume hyperbolic 3-manifold can be arbitrarily large. In contrast, Colin Adams and Alan Reid showed that the length of a shortest closed geodesic in a hyperbolic knot or link complement in S^3 is less than 7.171646... In this talk we will show that the length of an n^{th}-shortest closed geodesic ($n > 1$) in a hyperbolic knot complement in S^3 is also bounded above and we will produce an explicit upper bound for this length, which will be a logarithmic function of n. (Received August 21, 2008)

1046-51-281 **Aaron D Magid*** (magid@umich.edu), Department of Mathematics, 2074 East Hall, 530 Church St., Ann Arbor, MI 48109. *The Local Topology of Deformation Spaces of Kleinian Surface Groups.*

For any closed surface S, the deformation space AH(S) is the space of all marked hyperbolic 3-manifolds homotopy equivalent to S. After reviewing some of the classical results that describe topology of the interior of AH(S), we will show that there are certain points on the boundary where AH(S) is not locally connected. This is a generalization of Ken Bromberg's result that the space of Kleinian punctured torus groups is not locally connected. (Received September 02, 2008)

1046-51-290 **Sandra E Ritz*** (daoust@usc.edu), 221 S Lincoln Ave, Apt D, Monterey Park, CA 91755. *A Categorification of the Burau Representation using Contact Geometry.* Preliminary report.

A study of interesting dividing sets and their associated contact structures on $D_3 \times [0, 1]$, where D_3 is the disk with 3 punctured points, with a calculation of how the generators of the braid group B_3, viewed as the mapping class group of D_3, act upon them. This determines a matrix representation of B_3, which is related to the standard Burau representation. (Received August 25, 2008)

1046-51-310 **Ian Biringer*** (biringer@math.uchicago.edu) and **Juan Souto** (jsouto@umich.edu). *Finiteness Theorems for Hyperbolic 3-Manifolds.*

We will investigate the relationship between three invariants of closed hyperbolic 3-manifolds: injectivity radius, the rank of the fundamental group, and the first eigenvalue of the Laplacian. Using a theorem of Vigneras, we will then deduce that there are only finitely many commensurability classes of closed, arithmetic, hyperbolic 3-manifolds with bounded rank and injectivity radius. (Received August 25, 2008)

1046-51-321 **Schlicker Steven*** (schlicks@gvsu.edu), Department of Mathematics, 1 Campus Drive, Grand Valley State University, Allendale, MI 49401-9403. *Integer Sequences from Polygonal Chains in the Geometry of Compact Sets.*

The Hausdorff metric geometry provides fertile ground for much interesting and surprising mathematics. In this session, we will explore the concept of betweenness in this geometry and introduce a three-parameter family of new integer sequences that arise from special types of line segments defined by polygonal chains. (Received August 26, 2008)

1046-51-362 **Johanna Mangahas*** (mangahas@umich.edu), 1320 W Stadium Blvd Apt 5, Ann Arbor, MI 48103. *Uniform uniform exponential growth of subgroups of the mapping class group.*

Let Mod(S) denote the mapping class group of a compact, orientable surface S. We prove that finitely generated subgroups of Mod(S) which are not virtually abelian have uniform exponential growth with minimal growth rate bounded below by a constant depending only on S. (Received August 28, 2008)

1046-51-368 **Shinpei Baba*** (shinpei@math.ucdavis.edu). *Complex projective structures with Schottky holonomy.*

A Schottky group in $\mathrm{PSL}(2,\mathbb{C})$ induces an open hyperbolic handlebody and its ideal boundary is a closed orientable surface S whose genus is equal to the rank of the Schottky group. The boundary surface is equipped with a complex projective structure and its holonomy representation is an epimorphism from $\pi_1(S)$ to the Schottky group. We show that an arbitrary projective structure with the same holonomy representation is obtained by grafting the basic structure described above.

This result is an analogue to the characterization of the projective structures whose holonomy representation is an isomorphism from $\pi_1(S)$ to a fixed quasifuchsian group, which was given by Goldman in 1987. (Received August 28, 2008)

1046-51-527 **Nicholas L Michaud*** (nm367@bard.edu), 18 Malverna Rd., Boston, MA 02131, and **Liz Anet** (lm763@bard.edu), **Adam Chodoff** (ac194@bard.edu) and **Viriya Ratanasangpunth** (vr239@bard.edu). *On the realizability of certain graphs as Delaunay Tessellations.*

Given a graph G, Dillencourt et al. proved that G is realizable as a Delaunay tessellation if only if its stellation is inscribable. In this talk, we provide some conditions for graphs of n-gons with an arbitrary number of verticies inside the convex hull to be realizable as Delaunay tessellations using Dillencourt's results. We then consider the implications of such conditions on Voronoi Diagrams, which are the dual graphs of Delaunay tessellations. (Received September 06, 2008)

1046-51-611 **Max D. Engelstein*** (max.engelstein@yale.edu). *Least Perimeter Partitions of the Sphere into Equal Areas.*

We discuss least perimeter partitions of the sphere into n equal areas (where results are known only for $n = 2, 3$ and 12). Specifically we will discuss new results and methods in the $n = 4$ case. (Received September 09, 2008)

1046-51-756 **R KillGrove***, 2041 W. Vista Way 7245, Vista, CA 92083, and **L Taylor** and **D Koster**. *Two Neat Results In Elementary Geometry.*

Axioms of an ordered plane use the ternary relation ωABC, eg. *Self–Dual Confined Configuations With Ten Points,* **Ars Comb 67** (2003) 37–63. In E^2 for A:(A_1,A_2) and C:(C_1,C_2) with A$\neq$C and B:(B_1,B_2) satisfy ωABC iff $\exists\, t$, $0 < t < 1 \ni$ for i=1,2 B_i= tA_i+(1-t)C_i. For $\triangle$ $\mathrm{P}_1\mathrm{P}_2\mathrm{P}_3$ (triangle $\mathrm{P}_1\mathrm{P}_2\mathrm{P}_3$) and let $\triangle$ $\mathrm{Q}_1\mathrm{Q}_2\mathrm{Q}_3$ be where $\omega\mathrm{P}_1\mathrm{Q}_3\mathrm{P}_2$, $\omega\mathrm{P}_2\mathrm{Q}_1\mathrm{P}_3$, and $\omega\mathrm{P}_3\mathrm{Q}_2\mathrm{P}_1$ using the same t. Special case: A:(u,v), $0 < u < 1$, $v > 0$, B:(0,0), C:(1,0), A$'$:($1-t$,0), B$'$:($t+(1-t)u$, $(1-t)v$) C$'$:(tu, tv). The charm: areas of $\triangle$AB$'$C$'$, $\triangle$A$'$BC$'$, and $\triangle$A$'$B$'$C are equal. Koster has shown finite field planes (analytic geometry in the field) whose orders are congruent to 2 mod 3, except 2, satisfy all the axioms of an ordered plane except the Pasch axiom. These are ordered planes even though their defining fields are not ordered. (Received September 10, 2008)

1046-51-826 **Edward Souder Newkirk***, 1519 Paresky Center, Williamstown, MA 01267. *The Soap Bubble Problem on the Sphere.* Preliminary report.

What is the least-perimeter way to partition the surface of a sphere into n prescribed areas? For n=2, the solution is known. The problem has also been solved for n=3 (Masters, 1994) and for n=12 in the case of equal areas (Hales, 2002). We show simulations of equal-area partitions for n>3 and discuss progress on a general solution for n=4. (Received September 11, 2008)

1046-51-856 **Steven E. Broad*** (sbroad@nd.edu), 255 Hurley Hall, Notre Dame, IN 46556. *An index formula related to a conjecture of Loewner.*

We prove a geometric index formula which produces a "defect" term for the Loewner conjecture about the index of vector fields with isolated zeros of the form $\partial_{\bar{z}}^n f$ for functions $f : \mathbb{C} \to \mathbb{R}$. A recent result of F. Xavier allows the index of such vector fields to be computed in terms of the set of eigenvalues of the Hessian of f in the case $n = 2$. Our result extends this formula to all $n \geq 2$. The Loewner conjecture has a deep connection to the Carathéodory conjecture which states that a smooth, convex embedding of the 2-sphere into $\mathbb{R}^3$ has at least two umbilics. (Received September 12, 2008)

1046-51-963 **David W. Henderson*** (dwh2@cornell.edu). *Geometry is Natural.* Preliminary report.
There is some power in formalisms of geometry (whether differential, Euclidean, non-Euclidean, projective, or finite). However, there is little agreement about which formalisms to use and about how to describe them, with the result that the starting definitions, notations and analytic descriptions vary widely from textbook to textbook. What all of these different approaches have in common are underlying geometric intuitions of the basic notions such as straightness (geodesic), smooth, tangent, curvature, and parallel transport. In this talk, I will discuss some of the negative affects of formalism and how to avoid them thru geometric experiences. (Received September 13, 2008)

1046-51-998 **Alison McDonough*** (amcdonou@email.smith.edu), Department of Mathematics and Statistics, Smith College, Northampton, MA 01063, and **Amanda Cangelosi** (mocangelo@gmail.com), **Alethea Tschetterwood** (atschett@email.smith.edu), **Alexandra Berkoff** (aberkoff@gmail.com) and **Amy Wesolowski** (awesolow@email.smith.edu). *Tiling the Plane with Squares.*
In [1] it is shown that it is possible to tile the plane using exactly one square of each integral side-length. We will present new results stemming from this discovery dealing with the nature, the possibility, and the impossibility of square tilings.

[1] Henle, F. V. and Henle, J. M., "Squaring the Plane," *The Am. Math. Monthly*, 115(1): 3-12, 2008.
(Received September 13, 2008)

1046-51-1013 **Oscar Vega*** (ovega@csufresno.edu), Department of Mathematics, California State University, Fresno, 5245 North Backer Avenue M/S PB 108, Fresno, CA 93740-8001. *Flat flocks and generalized j-planes.*
In this talk we will see how generalized j-planes, a new class of finite translation planes, yield partitions of the Segre variety $\mathcal{S}_{n,n}$ into Veroneseans $\mathcal{V}_n$. These partitions, sometimes called flat flocks and that generalize flocks of $Q^+(3,q)$, first appeared in 2001 in an article by Bader, Cossidente and Lunardon. They were later linked, in 2005, to translation planes by Jha and Johnson. (Received September 13, 2008)

1046-51-1031 **Hasebe Kazuki*** (hasebe@dg.takuma-ct.ac.jp), Kohda 551, Takuma-cho, Mitoyo, Kagawa 769-1192, Japan. *On Unveiled Relations between Twistor and Quantum Hall Effect.* Preliminary report.
In this talk, I present recently unveiled relations between twistor theory and quantum Hall effect. Since the discovery in 80's, quantum Hall effects have much progressed in condensed matter community regardless of the developments of twistor theory, but recently, it has begun to be recognized that quantum Hall effects share many properties, such as enhanced (conformal) symmetry, fuzzy geometry and incidence relations, with twistor models. I will report such progress and related topics. Firstly, Hopf fibrations are introduced as an underlying common mathematical structure of twistor theory and quantum Hall effect. Next, I review recent developments on higher dimensional generalizations and supersymmetric extensions of quantum Hall effect, and emphasize their relations to twistor and supertwistor models. Finally, I speculate about possible applications to twistor theory from quantum Hall effect, showing several concrete examples. (Received September 14, 2008)

1046-51-1311 **J. Brock*** (jeff.brock@gmail.com), Department of Mathematics, Box 1917, Providence, RI 02912, and **H. Masur** and **Y. Minsky**. *Asymptotics of Weil-Petersson geodesics.*
I will describe joint work with H. Masur and Y. Minsky analyzing the asymptotics of Weil-Petersson geodesic rays in Teichmüller space via their associated *ending laminations*, which record combinatorial limits of the set of bounded length curves along the ray. Such laminations serve as complete invariants for the asymptote classes of recurrent rays, and give a characterization of *bounded geometry* for a ray. Dynamical consequences for the Weil-Petersson geodesic flow include its topological transitivity, density of the set of closed orbits, and the unboundedness of topological entropy on compact invariant subsets. (Received September 15, 2008)

1046-51-1534 **Roger Howe*** (howe@math.yale.edu), Yale University, New Haven, CT 06520, and **William Barker**. *Teaching the Erlanger Programm.*
The first topic of this presentation will be our recently published textbook, *Continuous Symmetry*, that tries to embody the spirit of Felix Klein's *Erlanger Programm* in a course on Euclidean plane geometry. The core of the book studies the geometry of the Euclidean transformations (isometries and similarities) of the plane. These are then applied in several ways: to understanding selected aspects of traditional geometry (e.g., the nine point circle); to understanding the possible symmetries of plane configurations (e.g., the wallpaper groups); and to understanding area. The transformational viewpoint can enrich all these topics of study.

This book is in fact about half of a course originally conceived as a journey of ideas from the discovery to non-Euclidean geometry (about 1830), through the insight of Klein (about 1870), to the formulation of the special theory of relativity by Einstein (1905). This presentation will discuss both the realized part, as presented in *Continuous Symmetry*, and the part still under construction. (Received September 15, 2008)

1046-51-1709 **Alan Horwitz*** (alh4@psu.edu), 25 Yearsley Mill Rd., Media, PA 19063. *Eellipses inscribed in, and circumscribed about, convex quadrilaterals.*

We discuss some results related to ellipses inscribed in, and circumscribed about, a convex quadrilateral, D, in the plane. In particular, we discuss Steiner's nice characterization of the most nearly circular ellipse which passes through the vertices of D. We also prove that there is a unique ellipse of minimal eccentricity, and a unique ellipse of maximal area, which passes through the vertices of D. Finally, if D is a parallelogram, let E be the unique ellipse of minimal eccentricity inscribed in D. We prove that that the smallest nonnegative angle between equal conjugate diameters of E equals the smallest nonnegative angle between the diagonals of D. (Received September 16, 2008)

1046-51-2014 **Robert D Knight*** (knightr@ohio.edu), 101 University Dr, Chillicothe, OH 45601. *7-Point Bundle Forms in Laguerre Planes.*

Bundle forms, generalizations of the Veblin-Young axiom of affine spaces, are essential to understanding basic structures occurring within Laguerre planes, including near planes and hyperbolic pencils of cycles. In this talk, we consider the 7-point bundle forms and the relationships they have with each other, as well as to the 6-, 5-, and 4-point bundle forms. The ultimate goals of this line of research are to complete the categorization of Laguerre planes with respect to bundle forms and, more generally, to solidify the foundations of the field of Laguerre geometry. Our approach is synthetic, thus avoiding algebraic complications that can arise when structure is removed from a geometry. (Received September 16, 2008)

52 ► Convex and discrete geometry

1046-52-77 **Wesley Pegden*** (pegden@math.rutgers.edu), Department of Mathematics, Rutgers University (New Brunswick), 110 Frelinghuysen Rd., Piscataway, NJ 08854. *Which sets are resilient to erosion?*

Given a subset X of $\mathbb{R}^n$, define the *erosion* $e_r(X)$ of X by the radius r as the set of points of X at distance $\geq r$ from the complement X^C of X. So we have

$$e_r(X) = X \setminus \bigcup_{y \in X^C} B(r,y), \tag{1}$$

where $B(r,y)$ denotes an open ball of radius r about y. We are interested in determining which sets are *resilient* to erosion by some radius $r > 0$; *i.e.,* which sets X are equivalent under a Euclidean similarity transformation to their erosion $e_r(X)$.

We answer this question by giving a complete and somewhat suprising characterization of resilient sets; in a certain sense, it is one part convex geometry, and one part 'fractal' geometry. While we characterize all convex resilient sets with simple geometric constraints, the rest of the characeterization comes from a natural correspondence between a certain class of resilient sets (which includes all nonconvex resilient sets) and 'scale-invariant' sets. (Received July 21, 2008)

1046-52-151 **Horst Martini*** (martini@mathematik.tu-chemnitz.de), Faculty of Mathematics, University of Technology Chemnitz, 09107 Chemnitz, Saxony, Germany. *Special convex sets in normed linear spaces.*

It is natural to extend problems and results from classical convexity to finite dimensional normed linear spaces (Minkowski spaces). In this talk several new results in this direction will be presented, all of them related to the study of special classes of convex bodies. These results refer to new characterizations of centrally symmetric convex bodies (by using suitably defined surface area measures in Minkowski spaces), the notion of reducedness in Minkowski spaces, and convex sets in normed planes having the circular hull property (which is closely related to the concept of constant width). These new results were obtained jointly with E. Makai, G. Averkov, and M. Spirova. (Received August 07, 2008)

1046-52-157 **Natalie Durgin*** (ndurgin@hmc.edu), Department of Mathematics, Harvey Mudd College, Claremont, CA 91711, and **Helen Highberger** (hhighberger@hmc.edu), **Jacob Scott** (jnscott@hmc.edu) and **Francis Edward Su** (su@math.hmc.edu). *Classifying the simplices of the 4-dimensional cube.*

A simplex of the 4-dimensional cube is the convex hull of any 5 distinct vertices of the cube. We find there are exactly 27 isomorphism classes of these simplices under symmetries of the cube, 10 of which are degenerate. Our methodology is based on geometric considerations that produce insights beyond computational enumeration. In particular, we provide a complete description of these simplex facets and how they can fit together in any triangulation. Using this, we are able to provide a graph representation of several triangulations of the 4-cube, leading to a new understanding about Mara's minimal triangulation. (Received August 07, 2008)

1046-52-192 **Javier Alonso**, **Horst Martini** and **Zokhrab Mustafaev*** (mustafaev@uhcl.edu), 2700 Bay Area Blvd., Department of Mathematics, University of Houston-Clear Lake, Houston, TX. *On Orthogonal Chords in Minkowski Spaces.* Preliminary report.

It is known that a convex plate of diameter 1 in the Euclidean plane is of constant width 1 if and only if any two perpendicular intersecting chords have total length at least 1. We show that, in general, this result cannot be extended to normed (or Minkowski) planes when the type of orthogonality is defined in the sense of Birkhoff. Inspired by this, we present also further results on intersecting chords in normed planes that are orthogonal in the sense of Birkhoff and in the sense of James. (Received August 21, 2008)

1046-52-576 **David G Larman*** (d.larman@math.ucl.ac.uk), Gower Street, London, WC1E 6BT, England. *Blocking numbers for l_p balls in three dimensions.* Preliminary report.

(Joint work with Selvinaz Szegin) The blocking number of a convex body C in Euclidean Space is the minimum number of non-overlapping translates of C which touch C and prevent, without overlapping, any other translate from touching C. A well known unsolved conjecture is that the blocking number of every convex body in 3 dimensions is at least 6. Here we show that, for l_p balls in 3 dimensions, $p < \infty$, the blocking number is at most 6. (Received September 08, 2008)

1046-52-586 **Paul R. Goodey** and **Wolfgang Weil*** (weil@math.uka.de), Universität Karlsruhe, 76131 Karlsruhe, Germany. *Generalized Averages of Section and Projection Functions.* Preliminary report.

A centrally symmetric star body $K \subset \mathbb{R}^d$ is known to be determined by the content of its k-dimensional central sections, $1 \leq k \leq d-1$. Groemer (1998) proved a corresponding result for arbitrary star bodies, by considering the content of half-sections. The latter gives rise to a function $s_k(K; L, v)$ on pairs (L, v), where L is a k-space and v is a unit vector in L. In 2006, we considered the average $\bar{s}_k(K; v)$ of $s_k(K; L, v)$ over all L that contain v and investigated whether the function $\bar{s}_k(K; \cdot)$ already determines K. Surprisingly, this is the case for small and large values of k, but not in general (e.g. not if $2d - 3k + 1 = 0$).

As an intermediate construction, for a fixed j-space M with $1 \leq j \leq k \leq d-1$ and $v \in M$, one may average $s_k(K; L, v)$, over all L containing M. The resulting function $\bar{s}_{jk}(K; \cdot)$ is defined on the flag manifold of pairs (M, v). Obviously, $\bar{s}_{kk}(K; \cdot) = s_k(K; \cdot)$ and $\bar{s}_{1k}(K; \cdot) = \bar{s}_k(K; \cdot)$. We show that $\bar{s}_{jk}(K; \cdot)$ determines K uniquely, for all $2 \leq j \leq k$.

Similar results for projection functions of convex bodies will also be discussed. (Received September 08, 2008)

1046-52-608 **Zsolt Langi*** (zlangi@math.bme.hu), Department of Geometry, Budapest University of Technology, Egry Jozsef u. 1., Budapest, 1111, Hungary. *On the Hadwiger numbers of topological disks.*

The Hadwiger number $H(S)$ of a topological disk S in the plane is the maximum number of pairwise nonoverlapping translates of S that touch S. It is well known that if S is convex, then $H(S) \leq 8$. A. Bezdek, K. and W. Kuperberg conjectured that the same upper bound holds for the Hadwiger numbers of starlike disks. A. Bezdek showed that $H(S) \leq 75$ for any starlike disk S.

Another question of A. Bezdek and Pach was whether there is a universal upper bound for the Hadwiger numbers of topological disks in general. A recent result of Cheong and Lee shows that the answer for this question is no.

In this talk, I present recent results about the Hadwiger numbers of topological disks and, in particular, about those of starlike disks. (Received September 09, 2008)

1046-52-643 **Jim Lawrence** (lawrence@gmu.edu), Dept. of Math. Sciences, George Mason University, 4400 University Drive, Fairfax, VA 22030, and **Walter Morris*** (wmorris@gmu.edu), Dept. of Math. Sciences, George Mason University, 4400 University Drive, Fairfax, VA 22030. *Finite Sets as Complements of Finite Unions of Convex Sets.*

Given a finite $S \subseteq \mathbb{R}^d$, how many convex sets are required to write the complement as a union? Crude estimates of the number of convex sets required are given. When the restriction of openness is added, tighter bounds are obtained as an application of a theorem of Björner and Kalai. Certain families of graphs and hypergraphs connected with the problem are introduced. (Received September 09, 2008)

1046-52-674 **Irena Swanson*** (iswanson@reed.edu), 3203 SE Woodstock Blvd, Portland, OR 97202. *Semiregular tessellations.*

A semiregular tessellation of a plane is a tessellation using only regular n-gons such that each vertex meets an adjacent shape in a vertex, and the configurations are the same at all vertices (up to rotation). There are only finitely many semiregular tessellations (eight or nine, in addition to the three regular tessellations, depending on how you count).

I will discuss how to render semiregular tessellations in quilt form, in particular, what are the geometric shortcuts that save time but possibly not the fabric. (Received September 09, 2008)

1046-52-838 **James M. Henle*** (jhenle@smith.edu), Clark Science Center, Smith College, Northampton, MA 01063, and **Frederick V. Henle** (fredhenle@gmail.com), athenahealth, Inc., 311 Arsenal St., Watertown, MA 02472. *Squaring and Not Squaring One or More Planes.*

$X \subseteq \mathbb{N}$ **tiles the plane** if there is a tiling of the plane consisting of exactly one square each of side-length n for every $n \in X$. In [1] we prove that $\mathbb{N}$ tiles the plane. It is easy to show that if X contains every sum of two distinct members of X, then X tiles the plane. We show here that if X contains no such sums then X doesn't tile the plane. We show in addition that the prime numbers do not tile the plane and that there is a set such that it and its complement each tile the plane.

[1] Henle, F. V. and Henle, J. M., "Squaring the Plane," *The Am. Math. Monthly*, 115(1): 3-12, 2008. (Received September 12, 2008)

1046-52-902 **Maria de los Angeles Alfonseca*** (maria.alfonseca@ndsu.edu), 300 Minard Hall, North Dakota State University, Fargo, ND 58105, and **Dmitry Ryabogin** and **Artem Zvavich**. *Intersection bodies with lower dimensional faces and Lonke's barrel zonoid.* Preliminary report.

It is not known if a zonoid whose polar is a zonoid always tends to the Euclidean ball as the dimension grows to infinity (although this is true for Schneider's zonoids). Since the dual of a zonoid is an intersection body, we address a weak version of this problem by constructing intersection bodies with lower dimensional faces and studying whether their duals are zonoids. In particular, we prove that Lonke's barrel zonoid is not an intersection body in dimensions 8 and higher, but it is an intersection body in dimensions 6 and lower. (Received September 12, 2008)

1046-52-999 **Emma Schlatter*** (eschlatt@email.smith.edu), Department of Mathematics and Statistics, Smith College, Northampton, MA 01063, and **Jessica Peterson**, **Sarah Rathnam** and **Emily Gunawan**. *Unfolding Convex Polyhedra.*

It is a long-unsolved problem to decide whether or not the surface of every convex polyhedron may be sliced along its edges and unfolded flat to one connected piece without overlap. (Such a planar shape is sometimes called a *net* for the polyhedron.) Cutting any spanning tree of the 1-skeleton of the polyhedron permits the surface to be unfolding flat, but no one has found a way to guarantee there will not be overlap. Nor is there a counterexample to the hypothesis that all convex polyhedra have such an unfolding.

We prove that a subclass of the prismatoids do indeed have a non-overlapping unfolding. A prismatoid is the convex hull of two convex polygons lying in parallel planes. We hope to extend our proof to all prismatoids. (Received September 13, 2008)

1046-52-1143 **Gábor Fejes Tóth*** (gfejes@renyi.hu), Rényi Institute, Reáltanoda utca 13-15, Budapest, H-1053, Hungary. *Shortest path among circles.* Preliminary report.

Given a packing of open unit circles, any two points lying outside the circles at distance d from one another can be connected by a path evading the circles and having length at most

$$\frac{2\pi}{\sqrt{27}}(d-2)+\pi\,.$$

This bound cannot be improved for values of the form $2(k\sqrt{3}+1)$. Can a packing of incongruent circles with radii at most 1 force us to a greater detour? The answer is yes, but concerning this problem we have to be satisfied with weaker upper and lower bounds for the length of the shortest path. (Received September 14, 2008)

1046-52-1252 **Monika Ludwig*** (mludwig@poly.edu). *General affine surface areas.*

In a joint work with Matthias Reitzner (Ann. of Math., to appear), we obtained the following classification of valuations on the space, $\mathcal{K}_0^n$, of convex bodies that contain the origin in their interiors.

Theorem. A functional $\Phi : \mathcal{K}_0^n \to \mathbb{R}$ is an upper semicontinuous and $\mathrm{SL}(n)$ invariant valuation that vanishes on polytopes if and only if there is a concave function $\phi : [0,\infty) \to [0,\infty)$ with $\lim_{t\to 0} \phi(t) = \lim_{t\to\infty} \phi(t)/t = 0$ such that

$$\Phi(K) = \int_{\partial K} \phi(\kappa_0(K,x))\, d\mu_K(x) \tag{1}$$

for every $K \in \mathcal{K}_0^n$.

Here $d\mu_K(x) = x \cdot u(K,x)\, dx$ is the cone measure on ∂K, $u(K,x)$ is the exterior normal unit vector to K at $x \in \partial K$, and

$$\kappa_0(K,x) = \frac{\kappa(K,x)}{(x \cdot u(K,x))^{n+1}},$$

where $\kappa(K,x)$ is the Gaussian curvature.

In this talk, two new families of general affine surface areas are defined. Basic properties and affine isoperimetric inequalities for these new affine surface areas as well as for the L_ϕ affine surface areas defined in (1) are discussed. (Received September 15, 2008)

1046-52-1257 **Jim Lawrence*** (lawrence@gmu.edu), Department of Mathematical Sciences, George Mason University, Fairfax, VA 22030. *Convex polytopes with abelian vertex-transitive symmetry.* Preliminary report.

In studying families of mathematical objects, it is often useful to single out those having a lot of symmetry in the hope that, for these, the analysis will be made less difficult by use of the symmetry. For convex polytopes, such a simplifying assumption might be that the polytope has a vertex-transitive group of symmetries. It is curious that such polytopes having more complicated groups of symmetries are often easier to study than those having, say, abelian groups of symmetries. We consider the problem of classifying the convex polytopes P for which there is an abelian group of linear symmetries acting transitively on the set of vertices. We consider in particular the case of 4-dimensional polytopes, an investigation fruitfully begun by Z. Smilansky. Here, there is an interesting connection between the combinatorial type of the polytope and continued fractions. This is joint work with T. Bisztriczky. (Received September 15, 2008)

1046-52-1393 **Boris Rubin*** (borisr@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Quaternionic Busemann-Petty problem.*

The classical Busemann-Petty problem (1956) asks, whether origin-symmetric convex bodies in $\mathbb{R}^n$ with smaller hyperplane central sections necessarily have smaller volumes. The answer is known to be affirmative if and only if $n \leq 4$. The same question for equilibrated convex bodies in $\mathbb{C}^n$ has an affirmative answer if and only if $n \leq 3$. We give a complete solution to a similar problem in the n-dimensional quaternionic space $\mathbb{H}^n$ regarded as a right (or left) $\mathbb{H}$-module. The method relies on the properties of cosine transforms on the unit sphere and provides alternative proofs also to the real and complex cases. Some other problems of integral geometry in spaces over algebras will be discussed. (Received September 15, 2008)

1046-52-1395 **Andras Bezdek*** (bezdean@auburn.edu), Department of Mathematics and Statistics, 221 Parker Hall, Auburn University, Auburn, AL 36849-5310, and **Jan P Boronski**, **Wesley Brown**, **Braxton Carrigan** and **Matt Noble**. *On a new proof of the Malfatti's problem.* Preliminary report.

The following problem was posed by Malfatti in 1803: How to arrange in a given triangle three non-overlapping circles of greatest total area? Malfatti assumed that the solution would be obtained by three mutually touching circles each touching also two edges of the triangle (commonly called as Malfatti's circles). Curiously, Malfatti had been wrong in his initial assumption. In 1930 Lob and Richmond observed that in an equilateral triangle the packing with one large inscribed triangle and two other inscribed in the remaining space is in fact better. In 1967 Goldberg outlined an argument, with graphical support, that Malfatti's arrangement never solves the area maximizing problem. It was no sooner than in 1992, when Zalgaller and Los showed that greedy arrangement is always the best (i.e. where one chooses the circles in three steps, each time choosing a maximal possible one).

In the present talk, by a simple non-analytic argument, we show that the solution to the original problem must be either the Malfatti arrangement or the greedy arrangement. Our approach can be used for the analogous question concerning perimeter, but more importantly it can be used to solve the analogous question for spherical triangles. (Received September 15, 2008)

1046-52-1511 **Michael J. Mossinghoff*** (mimossinghoff@davidson.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208. *Isodiametric problems for equilateral polygons.*

The maximal perimeter of a convex polygon having unit diameter and a fixed number of sides n is achieved only by certain equilateral polygons, provided that n has an odd prime divisor. Some prior work of the author and others considered the problem of constructing polygons with large perimeter when n is a power of 2. We describe how an experimental approach, combining numeric and symbolic computations, was employed in some recent investigations of two related problems about polygons. The first considers the construction of *equilateral* convex polygons with unit diameter, 2^m sides, and large perimeter. The second investigates the combinatorial problem of determining the number of essentially different polygons that exhibit the optimal perimeter for any fixed n. (Received September 15, 2008)

1046-52-1527 **Karoly Bezdek*** (bezdek@math.ucalgary.ca), Dept. of Math. and Stats., Univ. of Calgary, Calgary, Alberta T2N 1N4, Canada. *On partial coverings of convex bodies by planks.*

K. Bezdek raised the following problem at the "Intuitive Geometry, in Memoriam László Fejes Tóth" meeting (June 30-July 4, 08) in Budapest, Hungary: Let $\mathbf{B}$ be an o-symmetric convex body of minimal width 1 in $d-$dimensional Euclidean space $\mathbf{E}^d$. Moreover, let $w_1, w_2, \dots, w_n$ be positive real numbers satisfying the inequality $w_1 + w_2 + \cdots + w_n < 1$. Then prove or disprove that the planks $\mathbf{P}_1, \mathbf{P}_2, \dots, \mathbf{P}_n$ of width $w_1, w_2, \dots, w_n$ in $\mathbf{E}^d$ cover the largest possible volume of $\mathbf{B}$ if $\mathbf{P}_1 \cup \mathbf{P}_2 \cup \dots, \cup \mathbf{P}_n$ is a plank of width $w_1 + w_2 + \cdots + w_n$ with o being its center of symmetry. In the talk we present some partial results. (Received September 15, 2008)

1046-52-1564 **Shlomo Reisner*** (reisner@math.haifa.ac.il), Department of Mathematics, University of Haifa, 31905 Haifa, Israel. *Algorithmic approximation of convex polytopes by simpler convex polytopes.*

New results concerning algorithmic approximation of convex polytopes by simpler (having fewer vertices or faces) convex polytopes are presented with various ways to measure the rate of approximation. This is a joint work with Mario A. Lopez. (Received September 16, 2008)

1046-52-1692 **Dan Ismailescu*** (matdpi@hofstra.edu), Department of Mathematics, Hofstra University, Hempstead, NY 11549. *Class Preserving Dissections of Convex Polygons.* Preliminary report.

Given a convex quadrilateral Q having a certain property $\mathcal{P}$, we are interested in finding a dissection of Q into a finite number of smaller convex quadrilaterals, each of which has property $\mathcal{P}$ as well. In particular, we prove that every cyclic (orthodiagonal, circumscribed) quadrilateral can be dissected into cyclic (orthodiagonal, respectively circumscribed) quadrilaterals. The problem becomes much more interesting if we restrict ourselves to a particular type of partition we call *grid dissection.* Joint work with Adam Vojdany. (Received September 16, 2008)

1046-52-1767 **Marton Naszodi*** (mnaszodi@math.ualberta.ca), 632 Central Academic Building, Department of Mathematics & Statistics, University of Alberta, Edmonton, Alberta T6G 2G1, Canada. *On Covering a Convex Set with Its Smaller Copies.*

We consider two topics closely related to the Gohberg – Markus – Boltyanski – Hadwiger Problem, which is to prove that every convex body in $\mathbb{R}^n$ is illuminated by 2^n directions. First, we present a new equivalent formulation of the problem, and introduce a fractional version of the illumination number. We show that for symmetric convex bodies, this number is at most 2^n. As a corollary, we obtain that for any symmetric convex polytope with k vertices, there is a direction that illuminates at least $\frac{k}{2^n}$ vertices.

Next, we answer the following question that was posed as Problem 6 in Section 3.2 of [1]: Let H_n denote the smallest integer k such that for every convex body K in $\mathbb{R}^n$ there is a $0 < \lambda < 1$ such that K is covered by k translates of λK. Can λ be chosen independently of K; that is, is there a $0 < \lambda_n < 1$ depending on n only with the property that every convex body K in $\mathbb{R}^n$ is covered by H_n translates of $\lambda_n K$? We prove the affirmative answer. REFERENCES: [1] Brass, P.; Moser, W.; Pach, J. *Research Problems in Discrete Geometry.* Springer, New York, 2005. xii+499 pp. (Received September 16, 2008)

1046-52-1772 **David Alonso-Gutiérrez**, **Jesús Bastero**, **Julio Bernués** and **Paweł Wolff*** (pawel.wolff@case.edu), Case Western Reserve University, Mathematics Department, Yost Hall 220, 10900 Euclid Avenue, Cleveland, OH 44106-7058. *Remark on isotropic constant of projections of convex bodies.*

An estimate for the isotropic constant of orthogonal projections of a class of random convex bodies and ℓ_1^n-ball will be presented. In the case of projections onto subspaces which dimension is proportional to the dimension of the entire space, this estimate gives the boundedness of the isotropic constant. (Received September 16, 2008)

1046-52-1939 **Feng Luo*** (fluo@math.rutgers.edu), Dept of Math, Rutgers University, Piscataway, NJ 08854, and **David Gu**, SUNY at Stony Brook. *Discrete curvature flows and their applications, I.*

We will discuss several discrete curvature flows on triangulated surfaces and 3-manifolds. Some applications of them to computer graphics will also be addressed. (Received September 16, 2008)

1046-52-1955 **Satyan Devadoss** (satyan.devadoss@williams.edu), **Rahul Shah** (rahul.a.shah@williams.edu), **Xuancheng Shao** (zero@mit.edu) and **Ezra M Winston*** (ew429@bard.edu). *Nonconvex Polygons and Deformations of Associahedra.*

The $(n-2)$-dimensional associahedron K_n can be interpreted as the space of possible diagonalizations of a convex $(n+1)$-gon. We generalize the associahedron by considering diagonalizations of nonconvex polygons. We show that the polytopal complex corresponding to diagonalizations of a nonconvex $(n+1)$-gon is a contractible subcomplex of the associahedron K_n. (Received September 17, 2008)

1046-52-2006 **Jeffrey Schlaerth*** (jschlaer@math.kent.edu), The Department of Mathematical Sciences, Kent State University, Kent, OH 44242. *Local and Equatorial characterization of unit balls of subspaces of $L_p, p > 0$ and properties of the generalized cosine transform.*

In this talk we show that there is no local equatorial characterization of bodies that embed in L_p in *odd* dimensions for all p not even, $0 < p < \infty$. However, bodies that embed in L_p for p odd are local equatorially characterizable provided that the dimension is even but not locally characterizable in general. This extends results given by Panina; Goodey and Wiel; Nazarov, Ryabogin and Zvavitch concerning the local equatorial characterization of zonoids and intersection bodies. (Received September 16, 2008)

1046-52-2008 **Erwin Lutwak** and **Deane Yang*** (dyang@poly.edu), Six Metrotech Center, Brooklyn, NY 11201, and **Gaoyong Zhang**. *Convex geometry, Sobolev inequalities, and information theory.* Preliminary report.

Recent work by the authors and others on connections between convex geometry, Sobolev inequalities, and information theory will be presented. (Received September 16, 2008)

1046-52-2073 **Grigorios Paouris*** (grigoris_paouris@yahoo.co.uk), 2709 Wndwood Dr, College Station, TX 77845. *Supergaussian directions and the Hyperplane Conjecture.*

Let μ a log-concave isotropic probability measure in $\mathbb{R}^n$. We will discuss the connection of small ball probability estimates, existance of supergaussian directions for such a measure with a well known conjecture in Convex geometry , known as the Hyperplane Conjecture. (Received September 17, 2008)

1046-52-2082 **Jared Tanner*** (jared.tanner@ed.ac.uk), School of Mathematics, James Clerk Maxwell Building, Mayfield Road, Edinburgh, EH9 3JZ, Scotland, and **David L. Donoho**. *Phase transition phenomenon in sparse approximation.*

Compressed Sensing reconstruction algorithms typically exhibit a zeroth-order phase transition phenomenon for large problem sizes; there is a domain of problem sizes for which successful recovery occurs with overwhelming probability, and there is a domain for which recovery failure occurs with overwhelming probability. For ℓ^1-regularization, this phenomenon is a manifestation of the number of low dimensional faces of randomly projected polytopes. These results give precise if and only if conditions on the number of samples needed in Compressed Sensing applications. (Received September 17, 2008)

53 ► Differential geometry

1046-53-201 **Amine Fawaz*** (fawaz_a@utpb.edu), 4901 E. University, Mathematics, Odessa, TX 79762.
On the Volume of Meromorphic Vector fields on Riemann Surfaces. Preliminary report.

We define the volume of foliations on Riemann surfaces and we derive the associated Euler-Lagrange equations. We prove that holomorphic foliations are critical and we give upper and lower bounds for the volumes of meromorphic foliations; we also generalize the results for projectable meromorphic vector fields on principal circle bundles over Riemann surfaces. (Received August 18, 2008)

1046-53-211 **Christine Breiner*** (cbreiner@math.jhu.edu), 3400 North Charles Street, Krieger Hall 404, Baltimore, MD 21218. *Embedded minimal surfaces with finite topology.* Preliminary report.

The study of minimal surfaces with one end embedded in $\mathbb{R}^3$ is currently a rich area of research. We determine an explicit geometric decomposition for any complete, properly embedded minimal surface in $\mathbb{R}^3$ with finite genus and one end. As a corollary we show all such surfaces have Weierstrass data asymptotic to a helicoid. (Received August 19, 2008)

1046-53-217 **Michelle E Hackman*** (mehackma@indiana.edu), 2712 S. Banta Ave., Bloomington, IN 47403. *Screw-Motion Invariant Minimal Surfaces.*

If we twist the fence of catenoids, a well-known minimal surface, we get a new family of screw-motion invariant minimal surfaces. In my research, I found that the existence of such a surface depends on a complex number τ ($\mathrm{Im}[\tau] > 0$) and the angle of the screw-motion twist. I proved that for every τ there exists a surface for some screw-motion angle ψ. My talk will outline my results thus far, as well as conjectures about open questions. (Received September 15, 2008)

1046-53-267 **Sooran Kang*** (sooran@colorado.edu), 3000 Colorado Ave. #G227, Boulder, CO 80303.
Yang Mills functional on a deformed Heisenberg C^*-algebra.

In this poster, we present Yang-Mills theory for a deformed Heisenberg C^*-algebra, the deformation quantization of Heisenberg manifold, $D^{c,\hbar}_{\mu\nu}$, first invented by Marc Rieffel, using the noncommutative geometrical method developed by Alain Connes. In particular, we will describe a Grassmannian connection and its curvature on a projective module Ξ over the noncommutative C^*-algebra, $D^{c,\hbar}_{\mu\nu}$, and produce a specific element R in this projective module that determines both a non-trivial Rieffel projection and the curvature of the corresponding Grassmannian connection. Also, we will introduce the notion of multiplication-type elements of $E^{c,\hbar}_{\mu\nu}$. In our main result, we use a multiplication type operator to construct a certain family of connections on the deformed Heisenberg C^*-algebra that give rise to critical points of the Yang-Mills functional. (Received August 24, 2008)

1046-53-583 **Frank Morgan*** (Frank.Morgan@williams.edu), Department of Mathematics and Statistics, Williams College, 18 Hoxsey Street, Williamstown, MA 01267. *Isoperimetric balls in cones over tori.*

In the cone over a cubic three-torus T^3, balls about the vertex are isoperimetric if the volume of T^3 is less than pi/16 times the volume of the unit three-sphere. The conjectured optimal constant is 1. (Received September 08, 2008)

1046-53-673 **Corey A. Hoelscher***, 110 Frelinghuysen Road, Department of Mathematics, Piscataway, NJ 08854, and **Shari Ultman**. *The topology of low dimensional cohomogeneity one manifolds.* Preliminary report.

In essence, a cohomogeneity one manifold can be understood as a manifold with so much symmetry that every point can be carried to some point on a fixed line within the manifold by some transformation of the space. W. D. Neumann and J. Parker classified this type of manifold in dimensions 4 and lower and C. Hoelscher classified compact simply connected cohomogeneity one manifolds in dimensions 5, 6 and 7. In this talk we will discuss this classification and recent progress on understanding the topology of these manifolds. (Received September 09, 2008)

1046-53-1081 **S Adam Sikora*** (asikora@buffalo.edu), 244 Math Bldg, SUNY Buffalo, Buffalo, NY 14260. *3-manifolds whose character varieties are not Lagrangian.* Preliminary report.

W. Goldman proved that for every orientable closed surface F and a reductive (complex or real) Lie group G the G-character variety $X_G(F)$ of F is (real or holomorphic) singular symplectic manifold. Furthermore, he showed that for every oriented 3-manifold bounding F, the image of $X_G(M)$ is isotropic in $X_G(F)$. In fact,

$X_G(M)$ is a Lagrangian submanifold for most "easy to define" 3-manifolds. We will show explicit constructions of 3-manifolds for which $X_G(M)$ is not Lagrangian. (Received September 14, 2008)

1046-53-1093 **Peter Buser*** (peter.buser@epfl.ch), Professor Peter Buser, École Polytechnique Fédérale Lausanne, SB-IGAT-GEOM, Station 8, CH-1015 Lausanne, Switzerland, and **Hugo Parlier** (hugo.parlier@epfl.ch), Dr. Hugo Parlier, École Polytechnique Fédérale Lausanne, SB-SMA-GE, (BCH), CH-1015 Lausanne, Switzerland. *Graphical representation of the Birman-Series set on hyperbolic surfaces.* Preliminary report.

It is well known that complete geodesics on a compact negatively curved manifold are dense. In contrast to this, Birman and Series showed that in dimension two (and constant curvature), the sublocus of this set formed by the simple complete geodesics is nowhere dense. The lecture presents algorithms that compute this set up to a given degree of accuracy. A difficulty occurs from the fact that in negative curvature, geodesics spread with exponential speed. In the lecture it is shown how one may solve this without having to resort to ultra high precision. (Received September 14, 2008)

1046-53-1098 **Fernando Galaz-Garcia*** (galazg@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *On the classification of low-dimensional fixed point homogeneous Riemannian manifolds with nonnegative sectional curvature.* Preliminary report.

Let G be a compact Lie group acting isometrically on a compact Riemannian manifold M with nonempty fixed point set M^G. We say that M is *fixed point homogeneous* if G acts transitively on a normal sphere to some component of M^G. Simply connected fixed point homogeneous manifolds with positive sectional curvature have been completely classified. We will discuss the structure of fixed point homogeneous Riemannian manifolds with nonnegative curvature and their classification in low dimensions. (Received September 14, 2008)

1046-53-1117 **Florin Dumitrescu*** (fdd3@psu.edu), Pennsylvania State University, Department of Mathematics, University Park, PA 16802. *Connections and Parallel Transport.* Preliminary report.

This is a short note on the equivalence of the analytic definition of connections on vector bundles (as covariant derivatives) and the geometric definition of connections (as parallel transport). In a subsequent paper with Stephan Stolz we shall interpret connections as 1 dimensional topological field theories. (Received September 14, 2008)

1046-53-1148 **Timothy E Goldberg*** (goldberg@math.cornell.edu), Department of Mathematics, Malott Hall, Cornell University, Ithaca, NY 14850. *A convexity theorem for the real part of a Borel invariant subvariety.*

Brion proved a convexity result for the moment map image of an irreducible subvariety of a compact integral Kaehler manifold preserved by the complexification of the Hamiltonian group action. Guillemin and Sjamaar generalized this result to irreducible subvarieties preserved only by a Borel subgroup. In another direction, O'Shea and Sjamaar proved a convexity result for the moment map image of the submanifold fixed by an antisymplectic involution. Analogous to Guillemin and Sjamaar's generalization of Brion's theorem, the speaker generalized O'Shea and Sjamaar's result, proving a convexity theorem for the moment map image of the involution fixed set of an irreducible subvariety preserved by a Borel subgroup. (Received September 14, 2008)

1046-53-1189 **Idrisse Khemar*** (khemar@math.jussieu.fr), T.U. Munich, Zentrum Mathematik, Lehrstuhl Scheurle M 8, Boltzmannstr.3, D- 85747 Garching, Germany. *Geometric Interpretation of elliptic integrable systems associated to k-symmetric spaces.*

We give a geometrical interpretation of all the m-th elliptic integrable systems associated to a k-symmetric space G/G_0 (in the sense of C.L. Terng) in terms of vertically harmonic twistor lifts taking values in certain subbundle of the bundle $\mathrm{End}(TM)$, $M = G/H$ being a p-symmetric space associated to G/G_0. The general problem splits into three cases : the primitive case ($m < [(k+1)/2]$), the determined case ($m = [(k+1)/2]$) and the over determined case ($m > [(k+1)/2]$). The most interesting is the determined case which splits itself into two subcases: the even case (k is even) (for $k = 4$ our twistor space coincides with the bundle of almost complex structure in M), and the odd case (k is odd) in which we obtained in particular an interesting result: the second elliptic integrable system associated to a 3-symmetric space is the equation for (all) "holomorphically harmonic" maps into this 3-symmetric space. We will particularly insist on the case $m = 2$ in which will be all our examples: Hamiltonian Stationary Lagrangian surfaces into Hermitian symmetric space, surfaces with Holomorphic mean curvature vector into 4-dimensional symmetric spaces, constrained Willmore surfaces. (Received September 15, 2008)

1046-53-1315 **Michael S Gagliardo*** (mgaglia@ju.edu), Division of Math and Science, Jacksonville University, 2800 University BLVD N, Jacksonville, FL 32211. *The Higher Flows of Harmonic Maps.*

In the subject of integrable systems, there is a hierarchy of flows called the AKNS hierarchy (Ablowitz, Kaup, Newell and Segur). This hierarchy includes both the modified KdV equation and the nonlinear Schrödinger equation as well as others. The equations in the AKNS hierarchy are sometimes called the positive flows since each equation can be assigned a positive integer based on the element that generates the flow. The harmonic map equation can be seen as a -1 flow of the AKNS hierarchy and there is a hierarchy of negative flows associated with the harmonic map equation. The AKNS hierarchy can by realized in a loop group setting and the flows can be seen as resulting from a group action. By using a loop group setting, we can see that the two hierarchies are actually part of one large hierarchy and all of the flows commute. (Received September 15, 2008)

1046-53-1445 **Michael Hutchings*** (hutching@math.berkeley.edu), Mathematics Dept, 970 Evans Hall, University of California, Berkeley, CA 94720. *From Seiberg-Witten theory to closed orbits of vector fields: Taubes's proof of the Weinstein conjecture.*

Does every smooth vector field on a closed 3-manifold have a closed orbit? No, according to counterexamples by K. Kuperberg and others. On the other hand there is a special class of vector fields, called Reeb vector fields, which are associated to contact forms. The Weinstein conjecture asserts that every Reeb vector field on a closed oriented 3-manifold has a closed orbit. This conjecture was recently proved by Taubes using Seiberg-Witten theory. We will give an introduction to the Weinstein conjecture, the main ideas in Taubes's proof, and the bigger picture into which it fits. (Received September 15, 2008)

1046-53-1585 **K.-D. Semmler*** (klaus-dieter.semmler@epfl.ch), EPFL-SB-IGAT, Station 8, 01004 Lausanne, Switzerland. *Hyperbolic Polygons, Fuchsian groups and Helling Matricies.*

We will show the usage of linear algebra for hyperbolic geometry and Fuchsian groups. Even though we might get not as much milage out of linear algebra in this context as euclidian geometry has for centuries, it is in our view a very promising approach. Many properties in hyperbolic geometry have a strikingly easy formulation and proofs in this language. Furthermore for algorithmic and numeric purposes this way of looking at hyperbolic geometry and discreteness seems to us the most efficient way.

First we give some examples of geometric facts about polygons to show how linear algebra works for us. Then we interpret polygons as systems of generators of groups and study discreteness and quotients for simple cases, in particular genus 2, (1,2), and 3. Finally we propose some algorithms for moving around in Teichmüller space to get geometric information like systoles and Bers' constants. (Joint work with Anthony Arnold (EPFL)). (Received September 16, 2008)

1046-53-1802 **Christopher R Lee*** (crlee@math.uiuc.edu), 1409 W. Green St., MC-382, Urbana, IL 61801. *Folded Toric Four-Manifolds.* Preliminary report.

A folded symplectic form on a manifold is a two-form that is symplectic away from a hypersurface in the manifold and whose degeneracies are well-controlled on the hypersurface. When the hypersurface is empty, we arrive at a generalization of the notion of a symplectic manifold. If an n-torus acts effectively on a compact, connected 2n-manifold in a Hamiltonian fashion with respect to a folded symplectic form (i.e., if there is a moment map for the action), we say it is a folded toric manifold. Classifying folded toric manifolds is made difficult due to the lack of connectivity of fibers of the moment map. The intent of this report is to discuss the classification of folded toric four-manifolds and, in particular, to highlight the obstructions to extending locally isomorphic models to global ones in a unique way. (Received September 16, 2008)

1046-53-1827 **Katharine Walker*** (kaceyw@umich.edu), 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109. *Connected components of strata of quadratic differentials over Teichmuller space.*

In this talk we consider the connected components of strata of the moduli space of quadratic differentials lying over Teichmuller space. We use certain general properties of sections of line bundles to put an upper bound on the number of connected components, and a generalized version of the Gauss map as an invariant to put a lower bound on the number of such components. For strata with sufficiently many zeros of the same order, we can state precisely the number of connected components. (Received September 16, 2008)

1046-53-1898 **Ralph Howard*** (howard@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208. *Variational formulas for the isotropic constant.* Preliminary report.

A bounded domain, D, of $\mathbf{R}^n$ is in *isotropic position* iff its volume is one, its center of mass is the origin, and for some positive constant $L(D)$ (the *isotropic constant* of D)

$$\int_D x_i x_j \, d\mathrm{Vol} = L(D)\delta_{i\,j}.$$

If D is not in isotropic position, then there is an affine map, A, of $\mathbf{R}^n$ such that AD is in isotropic position and then define $L(D) = L(AD)$. We give variational formulas for L for as D varies over domains with smooth boundary and study the extremal domains from the point of view of differential geometry. (Received September 16, 2008)

1046-53-2028 **Ivko Dimitric*** (ivko@psu.edu), Mathematics Dept., Penn State University Fayette, Uniontown, PA 15401. *Some CR-submanifolds of low Chen-type in complex space forms.* Preliminary report.

We consider certain classes of CR-submanifolds $x : M^n \to \mathbb{C}Q^m$ of non-flat complex space forms whose Chen type is 2 or 3, via the immersion $\Phi : \mathbb{C}Q^m \to H(m+1)$ into the (pseudo) Euclidean space of Hermitian matrices by projection operators. According to B. Y. Chen, a submanifold of Euclidean space is said to be of finite type ($k-$type) if the position vector allows a decomposition into a sum of a constant vector and finitely many (k) vector-eigenfunctions of the Laplacian. The immersion whose type we are studying here is $\tilde{x} = \Phi \circ x$. We classify Hopf hypersurfaces of 2-type in $\mathbb{C}Q^m$ and CMC Hopf hypersurfaces of $\mathbb{C}Q^2$ which are mass-symmetric and of 3-type (e.g. the tubes about the complex quadric). For higher codimension, the most promissing study involves either the holomorphic or the totally-real submanifolds. We prove some nonexistence results for 2-type submanifolds such as for the holomorphic ones in $\mathbb{C}H^m(-4)$ and for ruled hypersurfaces in $\mathbb{C}Q^m$. We give geometric characterizations of Lagrangian submanifolds (mass-symmetric or with parallel mean curvature vector)in $\mathbb{C}Q^m$ as well as of complex hypersurfaces of 3-type in complex space forms. (Received September 16, 2008)

54 ► General topology

1046-54-93 **Benjamin J Benoy*** (benoy@math.ucsb.edu), University of Redlands, Department of Mathematics, 1200 East Colton Ave, P.O. Box 3080, Redlands, CA 92373. *A projective version of the Poincare polyhedron theorem.* Preliminary report.

I will discuss a generalization of Poincare's polyhedron theorem from the constant curvature geometries to the projective setting. Given a collection of convex polyhedra in Real Projective space, and a scheme for gluing faces via projective transformations, I will give conditions for the resulting quotient to have a real projective structure compatible with the gluings. The main condition concerns the holonomy around a codimension two face and is a direct analogue of the angle sum condition in the constant curvature version of the theorem. (Received July 22, 2008)

1046-54-213 **Vera Tonic*** (vtonic@ou.edu), University of Oklahoma, Department of Mathematics, PHSC, 601 Elm Ave, Norman, OK 73019. *Bockstein basis and resolution theorems in extension theory.*

Resolution refers to a map $\pi : Z \to X$ between topological spaces, where the domain is somewhat better than the range, and the map's fibers meet certain requirements.

Resolution theorems produce maps $\pi : Z \to X$ between a domain of finite covering dimension dim, and a range of finite cohomological dimension $\dim_G$, with cell-like or G-acyclic fibers. We will look at standard resolution theorems by Edwards-Walsh, Levin and Rubin-Schapiro, and discuss a generalization of Edwards-Walsh resolution theorem. (Received August 19, 2008)

1046-54-215 **Nathan A Carlson*** (ncarlson@math.arizona.edu), Department of Mathematics, Univ. Arizona, 617 N. Santa Rita Ave., P.O. Box 210089, Tucson, AZ 85721–0089, and **Guit-Jan Ridderbos**, Faculty of Sciences, Dept. of Mathematics, Vrije Universiteit, De Boelelaan 1081A, 1081 HV Amsterdam, Netherlands. *A new cardinality bound on homogeneous topological spaces via the Erdös-Rado theorem.*

In 1978 E. van Douwen demonstrated that well-known cardinality bounds on Hausdorff topological spaces can be improved if the space is presumed to be homogeneous. Using the Erdös-Rado Theorem, we give a substantial improvement on the van Douwen bound, answering a question of Jan van Mill. Partition relations have previously been used to prove cardinality bounds, but our result appears to be the first application of a partition relation in the context of homogeneity. (Received August 19, 2008)

1046-54-305 **Kim J Huerter*** (khuerter@math.uiowa.edu), 608 1/2 Ronalds St., Iowa City, IA 52245. *Non-Uniform Thickness of Smooth Knots.*

O. Gonzalez and J. Maddocks describes the uniform thickness of a smooth knot by taking the minimal radius of a circumcircle defined by three distinct points along the curve. A formula for the non-uniform thickness of a smooth knot is a generalization of this formula that allows for a non-uniform distribution of forces along the knot. (Received August 25, 2008)

1046-54-575 **Hueytzen J Wu*** (kfhjw00@tamuk.edu), Department of Mathematics, Texas A&M University-Kingsville, Kingsville, TX 78363, and **Wan-Hong Wu** (dd1273@yahoo.com), 7703 Floyd Curl Drive, San Antonio, TX 78229. *An open C*(D)-filter process of compactifications and generalized Stone-Weierstrass theorems.*

By means of a characterization of compact spaces in terms of open C*(D)-filters induced by a subset D of C*(X), an open C*(D)-filter process of compactification of an arbitrary topological spaces X is obtained by embedding X as a dense subspace of (X*, T) where X* = [P : P is an open C*(D)-filter on X], U* = [P : U is in P] and T is the topology induced by the base B = [U* : U is a nonempty open set in X] for X*. An arbitrary Hausdorff compactification (Z, h) of a Tychonoff space X can be obtained from D = [f : f = *f o h, *f is in C(Z)], a base G(D) for X and X* = [F : F is a basic G(D)-filter on X] by the open C*(D)-filter process of compactification. Finally, necessary and sufficiend conditions for vector sublattices or subalgebras to be dense in C(Z), C*(X) or C*(Y) are provided as generalized Stone-Weierstrass theorems, where Z, X and Y are a copact Hausdorff space, a Tychonoff space and an arbitrary topological space, respectively. (Received September 08, 2008)

1046-54-955 **Scott Morrison*** (scott@tqft.net), 2233 CNSI Building, UC Santa Barbara, Goleta, CA 93106, and **Clark David** and **Kevin Walker**. *The 2-point and 4-point Khovanov categories.*

I'll describe some results about the "2-point" and "4-point" Khovanov categories; these are the places where the Khovanov invariants of tangles with 2 and 4 boundary points live. Everything I say about the 2-point category will be "old", but said in a new way. (This includes a streamlined treatment of Rasmussen's s-invariant, for example.) About the 4-point category I can't say quite as much, but can give a nice result about the Khovanov homology of any rational tangle. (Received September 13, 2008)

1046-54-1139 **Lakeshia R. Legette*** (llegette@jcsu.edu), Johnson C. Smith University, Department of Natural Sciences & Mathematics, 100 Beatties Ford Rd., Charlotte, NC 28216. *Maximal groups in the Stone-Cech Compactification the free semigroup.*

Given any idempotent, p, in a discrete semigroup (S), there is a largest group H(p) with p as its identity. It will be shown that it is consistent that if (S) is the free semigroup or free group on countably many generators, there exist idempotents in beta(S) whose maximal group is a singleton. The same conclusion holds if (S) is the set of finite subsets of omega under the operation of union. (Received September 14, 2008)

1046-54-1247 **Jennifer M Franko*** (frankoj2@scranton.edu), The University of Scranton, Department of Mathematics, St. Thomas Hall, 162, Scranton, PA 18510. *Finite Image Braid Group Representations from the Yang Baxter Equation.*

This talk considers the images of the braid group under representations afforded by the Yang Baxter equation when the solution is a nontrivial 4 x 4 matrix. Making the assumption that all the eigenvalues of the Yang Baxter solution are roots of unity, leads to the conclusion that all the images are finite. (Received September 15, 2008)

1046-54-1273 **Shing S So*** (so@ucmo.edu), Dept. of Math. & Comp. Sci., University of Central Missouri, Warrensburg, MO 64093. *Some Extensions of Semi-closure Spaces.* Preliminary report.

Let X be a nonempty set and $P(X)$ the power set of X. A single-valued function c of $P(X)$ into $P(X)$ is called a *semi-closure operator on* X if it satisfies the following conditions:

C1. $c(\emptyset) = \emptyset$,

C2. $A \subset c(A)$ for each $A \in P(X)$,

C3. for each $A, B \in P(X)$, $A \subset B$ implies $c(A) \subset c(B)$, and

C4. $c(A) = c(c(A))$ for each $A \in P(X)$.

The pair (X, c) or simply X is called a *semi-closure space*.

In this paper, we will discuss some extensions of semi-closure spaces. (Received September 15, 2008)

1046-54-1444 **Wladyslaw Kulpa** and **Andrzej Szymanski*** (andrzej.szymanski@sru.edu), Department of Mathematics, Slippery Rock University, Slippery Rock, PA 16057. *Fixed point theorems for n-continuous L^*-operators.* Preliminary report.

An L*-operator on a topological space X is a function L defined on the set of all non-empty finite subsets of X (=Fin(X)) into exp(X) satisfying the following condition: (*) If A is in Fin(X) and U(x):xA is an open cover of X, then there exists a non-empty subset B of A such that the family consisting of L(B)U(x):xB, has a non-empty intersection. An L*-operator L on a topological space X is said to be n-continuous at a point p if each neighborhood U of p contains a neighborhood V of p such that L(A)is contained in U for each at most n+1 element subset A of V. Main Theorem. Let X be a Hausdorff space that admits an n-continuous L*-operator for some n >0. Then each continuous function f from X into X such that the closure of f(X) is a compact subspace of X of the covering dimension at most n has a fixed point. (Received September 15, 2008)

1046-54-1528 **Frederic Mynard**, Georgia Southern University, Department of Mathematical Sciences, P.O. Box 8093, Statesboro, GA 30460, and **Tom Richmond*** (tom.richmond@wku.edu), Western Kentucky University, Department of Mathematics, 1906 College Heights Blvd., Bowling Green, KY 42101. *The lattice of locally convex topologies on an ordered set.* Preliminary report.

A topology τ on a partially ordered set $(X, \leq)$ is *locally convex* if it has a base of $\leq$-convex sets. We consider the lattice of all locally convex topologies on certain ordered sets and discuss lattice complementation in this setting. (Received September 15, 2008)

1046-54-1626 **sarah-marie belcastro*** (smbelcas@toroidalsnark.net). *Braid words in generalized helix stripe patterns.*

When multiple strands of yarn are used in knitting (as, for example, when knitting with more than one color), a knitter twists a pair of strands when switching from using one to using another. The yarn strands between the knitting and the balls of yarn get tangled as the knitting proceeds. In turn, this produces a braid in the strands. This talk will consider the special case of the braid words generated by generalized helix stripe patterns. The basic technique produces spiralling stripes of row-height one. (Standard striping produces cylindrical or line-segment stripes.) We will first explain how to generalize helix striping to thicker stripes and different numbers of colors. We will then determine which braid words are generated using generalized helix stripe patterns. (This has practical applications in terms of detangling yarn while knitting.) (Received September 16, 2008)

1046-54-1711 **Samuel Jacob Behrend*** (behren_s@denison.edu), Slayter Box 7696, Denison University, Granville, OH 43023. *A Math Classic: The Tale of Three Links.*

Recently there has been considerable work done on the linking properties of spatial graphs, spurred by Conway, Gordon and Sach's seminal result regarding K_6. Specifically, they were able to prove that K_6 was intrinsically linked – every embedding of K_6 contains at least one two-component link. Flapan, et. al. proved that the minimal number of vertices needed for a triple link (links with *three* components) is 10. In the same article they provided a non-straight-edge embedding of K_9 without a triple link. In this work we consider triple links in the more restrictive geometric setting of straight-edge embeddings. Straight-edge embeddings are relevant to molecular chemists who synthesize knotted molecules – atoms and their bonds resemble straight-edge graphs. We establish results that determine when certain linear subgraphs of K_{10} are triple linked as well as certain linear embeddings of K_9. Using new techniques, we give an alternative proof to Flapan's result restricted to straight-edge embeddings. (Received September 16, 2008)

1046-54-2061 **Mieczyslaw K. Dabkowski*** (mdab@utdallas.edu), University of Texas at Dallas, Department of Mathematical Sciences, Richardson, TX 75080, and **Malgorzata A. Dabkowska**, **Valentina S. Harizanov**, **Jozef H. Przytycki** and **Michael A. Veve**. *Compactness of the space of left orders.*

A left order on a magma (e.g., semigroup) is a total order of its elements that is left invariant under the magma operation. A natural topology can be introduced on the set of all left orders of an arbitrary magma. We prove that this topological space is compact. Interesting examples of nonassociative magmas, whose spaces of right orders we analyze, come from knot theory and are called quandles. Our main result establishes an interesting connection between topological properties of the space of left orders on a group, and the classical algebraic result by Conrad and Los concerning the existence of left orders. (Received September 17, 2008)

1046-54-2085 **S Gukov*** (gukov@theory.caltech.edu), Caltech 452-48, Pasadena, CA 91125. *Matrix factorizations of colored MOY graphs.*

I will introduce a natural generalization of the matrix factorizations used by Khovanov and Rozansky in their construction of the sl(N) link homology. It seems this generalization should lead to a categorification of the colored MOY invariant. (Received September 17, 2008)

55 ► Algebraic topology

1046-55-55 **Kyle M. Ormsby*** (ormsby@umich.edu), Department of Mathematics, 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109-1043. *Some remarks on 2-completed motivic homotopy theory and the motivic J-homomorphism.*

I will talk about 2-complete $\mathbb{P}^1$-stable motivic homotopy theory over an algebraically closed field of characteristic 0 and a motivic analogue of the Adams-Novikov spectral sequence. I will also discuss Voevodsky's stratification of motivic Eilenberg-MacLane spaces with associated graded pieces given by certain reduced symmetric products of $\mathbb{P}^1$. As an application, I will present interesting new phenomena like elements of the stable stem mapping to 0 in etale homotopy. I will also discuss the image of a motivic analogue of the complex J-homomorphism (with domain algebraic K-theory). This project is in part joint with Igor Kriz and Po Hu, and owes much to discussions with Dan Isaksen, whose joint work with D. Dugger and O. Roendigs it complements to a certain extent. (Received July 16, 2008)

1046-55-135 **Xiaoxue H Li*** (xli@ehc.edu), Department of Mathematics, Emory & Henry College, P.O. Box 947, Emory, VA 24327. *Some properties of the v_1-periodic spectra associated to exceptional Lie groups.*

Bendersky, Bousfield, Davis, and Mohowald calculated v_1-periodic homotopy groups for many compact simple Lie groups. An important construction in these calculations was a spectrum ΦX associated to a topological space X, which satisfies $\pi_*(\Phi X) = v_1^{-1}\pi_*(X;p)$. Bousfield proved that the p-exponent of the spectrum ΦX is the same as the p-exponent of the group $K^1(\Phi X) = PK^1(X)/\psi^p$. We calculate the summand decomposition of $K^1(\Phi X)$ and get the p-exponent as the largest summand. We accomplish this for all exceptional Lie groups X and all odd primes p and compare them with the known p-exponent of the homotopy group $\pi_*(\Phi X)$. Our second result is to interpret the way the spectrum ΦX is built. We proved that ΦX can be built up from various ΦS^{2i+1} by fibrations. We then analyzed how these cells ΦS^{2i+1}'s were attached together. The attaching maps between cells were detected by the Adams module and the v_1-periodic homotopy groups. For all exceptional Lie groups at all odd primes p, we obtain a nice picture of how the ΦS^{2i+1}'s are attached together to build ΦX. (Received August 02, 2008)

1046-55-156 **Thomas M. Fiore*** (fiore@math.uchicago.edu), Department of Mathematics, University of Chicago, 5734 South University, Chicago, IL 60637, and **Simona Paoli** and **Dorette Pronk**. *The Homotopy Theory of n-fold Categories.*

When are two categories the same? One possible notion of weak equivalence is an equivalence of categories, another is a functor whose nerve is a weak homotopy equivalence of simplicial sets. As is well known, these distinct notions of weak equivalence between categories have been encoded in model structures by Joyal-Tierney and Thomason. One can ask the same question for Ehresmann's internal categories in Cat: when are two double categories the same? There are several reasonable notions of weak equivalence. Together with Simona Paoli and Dorette Pronk, we have incorporated them into model structures. One intriguing aspect of the Thomason structure on Cat is that it is Quillen equivalent to SSet and hence also Top. In this talk I will also report on recent progress on a model structure for n-fold categories which extends the Thomason structure on Cat. This is joint work with Simona Paoli. (Received August 07, 2008)

1046-55-158 **Son P Nguyen*** (npson@math.wayne.edu), 656 W Kirby st, Office 1150, Detroit, MI 48202. *Connective K-theory of certain symmetric groups.*

Connective K-theory interpolates between, and links, integral homology and K-theory, and as such is reasonably calculable. We describe recent results on the connective K-theory of symmetric groups, as well as Eilenberg-MacLane spaces. The latter suggest an inductive approach similar to Rusin's calculation of the cohomology of 2-groups. (Received August 07, 2008)

1046-55-160 **James R. Gillespie*** (jrg21@psu.edu). *Gorenstein model structures and generalized derived categories.*

We will see how the derived category of a ring can be constructed using Gorenstein homological algebra. Furthermore, this approach points to a theory of generalized derived categories. The method is to put a model structure on the category of graded $S[x]/(x^2)$-modules where S is a Gorenstein ring. Taking S to be the integers, the model structure can then be lifted to $R[x]/(x^2)$-modules where R is any ring. Its homotopy category recovers the derived category of R. By replacing $S[x]/(x^2)$ with other graded Gorensein rings, we are led to various generalizations of the usual derived category. We will give examples involving double complexes, and what we call k-chain complexes. (Received August 08, 2008)

1046-55-177 **Weiwei Pan***, Wesleyan University, Department of Mathematics, Middletown, CT 06459. *Categorified Bundles and Classifying Spaces.*

In the pursuit of geometrically defined cohomology theories, certain generalizations of the theory of vector bundles are studied. For a particular type of 2-category, Baas, Bökstedt and Kro define an associated concept of principal 2-bundles. They showed that the geometric nerve of a suitable 2-category is the classifying space of the associated principal 2-bundles. When the 2-category is actually a 2-group, Baez and Stevenson proved that principal 2-bundles are also classified by “non-abelian cohomology”. We define a notion of equivariant 2-bundles, and discuss their classifying spaces as well as their relation to generalized representations of groups. (Received August 12, 2008)

1046-55-214 **Valerie J. Peterson*** (vpeterso@uiuc.edu), Department of Mathematics, 1409 West Green Street, Urbana, IL 61801. *State Complexes and Special Cube Complexes.*

We present a topological, geometric, and group theoretic investigation into two related classes of CW-complexes. A **state complex** is a cubical complex that records the legal configurations of some moving system, as well as information about when system agents can move simultaneously. This is useful in robotic motion planning and other settings, both applied and abstract. A **special cube complex** is one whose hyperplanes avoid certain pathological interactions; these complexes are closely related to right-angled Artin groups, as are state complexes. (Received August 19, 2008)

1046-55-279 **David Pengelley*** (davidp@nmsu.edu), Mathematical Sciences, MSC 3MB, New Mexico State University, Las Cruces, NM 88003, and **Frank Williams** (frank@nmsu.edu), Mathematical Sciences, MSC 3MB, New Mexico State University, Las Cruces, NM 88003. *Unstable module presentations for the cohomology of real projective spaces.*

There is much we still do not know about projective spaces. We describe here how the cohomology of each real projective space is built as an unstable module over the mod two Steenrod algebra $\mathcal{A}$, or equivalently, over $\mathcal{K}$, the algebra of inherently unstable “lower operations” originally introduced by Steenrod. In particular, to produce the cohomology of projective space of each dimension we consider the well-known minimal set of unstable module generators and construct a minimal set of unstable relations. Two new perspectives we blend for this purpose are

- to focus solely on the two-power Steenrod squares that generate $\mathcal{A}$ to understand the $\mathcal{A}$-action in a process we call “shoveling ones”, and.
- to describe every element in a canonical way from a particular unstable generator by composing operations from the algebra $\mathcal{K}$

(Received August 25, 2008)

1046-55-355 **Julie Bergner*** (jbergner@math.ucr.edu). *Homotopical versions of Hall algebras.* Preliminary report.

The classical notion of the Hall algebra associated to an abelian category plays an important role in representation theory due to its relationship with quantum groups. However, in more recent attempts to strengthen this connection, the need has arisen for a higher-order or homotopical version of the Hall algebra. In this talk we'll look at “derived Hall algebras” associated to certain model categories or more general homotopy theories and give a brief look at why they are useful. (Received August 27, 2008)

1046-55-416 **J. Peter May*** (may@math.uchicago.edu), Department of Mathematics, The University of Chicago, Chicago, IL 600637. *Permutative and bipermutative categories revisited.*

It has been understood since 1972 that grouplike permutative categories are equivalent to connective spectra and grouplike bipermutative categories are equivalent to connective E infinity ring spectra. I'll give some modern variants on the theme of connecting categories with spectra, including some open questions that have recently arisen. One in particular concerns the analogue for spectra of the relationship between homotopy n-types and weak n-categories. A starting point, more or less understood in 1984 and recently rediscovered by algebraic geometers, relates Poincare groupoids to spectra with two non-vanishing homotopy groups. (Received September 03, 2008)

1046-55-459 **Thomas Wanner*** (twanner@gmu.edu), Department of Mathematical Sciences, George Mason University, Fairfax, VA 22030. *Homology Computations for Random Nodal Domains.*

Stochastic evolution equations frequently generate complex time-evolving patterns which are hard to quantify due to the lack of any underlying regular structure. The influence of stochasticity leads to variations in the details of the patterns and forces one to concentrate on rougher common geometric features. In many of these instances, such as in phase-field type models, one is interested in the geometry of nodal domains of a function in terms of their homology. Recent computational advances make it possible to compute the homology of discrete structures efficiently and fast. Such methods can be applied to the above situation if the nodal domains of interest are approximated using an underlying discretization. Yet, this method immediately raises questions concerning the accuracy of the computed homology and the appropriate location of the discretization points. In this talk, I present a probabilistic approach which gives insight into the suitability of the above method in the context of random fields. We obtain explicit probability estimates for the correctness of the homology computations, which in turn yield a-priori bounds for the suitability of certain grid sizes as well as information on the optimal location of sampling points. (Received September 03, 2008)

1046-55-479 **Yuliy Baryshnikov** and **Robert Ghrist*** (ghrist@seas.upenn.edu), 200 S. 33rd St., Philadelphia, PA 19104. *Euler characteristic, integration, and definable functions.* Preliminary report.

We consider integration with respect to Euler characteristic, a well-studied subject in the intersection of geometric combinatorics and constructible sheaves, which uses the Euler characteristic as a measure. We show how to extend the integral operator to real-valued integrands which are definable with respect to an o-minimal structure. In this theory, the integral operator is no longer linear; however, it does return a weighted combination of critical values of the integrand, and thus has strong connections to Morse theory.

This talk will present this integration theory and give applications to sensor networks involving target enumeration and localization. (Received September 04, 2008)

1046-55-563 **William C Kronholm*** (wkronho1@swarthmore.edu), Department of Mathematics and Statistics, Swarthmore College, 500 College Ave, Swarthmore, PA 19081. *The $RO(G)$-graded Serre Spectral Sequence.*

In this paper the Serre spectral sequence is extended from Bredon cohomology to $RO(G)$-graded cohomology for finite groups G. Special attention is paid to the case $G = \mathbb{Z}/2$ where the spectral sequence is used to compute the cohomology of certain projective bundles and loop spaces. (Received September 08, 2008)

1046-55-597 **John C. Baez*** (baez@math.ucr.edu), Department of Mathematics, University of California, Riverside, CA 92521. *Classifying Spaces for Topological 2-Groups.*

Categorifying the concept of topological group, one obtains the notion of a topological 2-group. This in turn allows a theory of "principal 2-bundles" generalizing the usual theory of principal bundles. It is well-known that under mild conditions on a topological group G and a space M, principal G-bundles over M are classified by either the Čech cohomology $H^1(M, G)$ or the set of homotopy classes $[M, BG]$, where BG is the classifying space of G. Here we review work by Bartels, Jurco, Baas-Bökstedt-Kro, Stevenson and myself generalizing this result to topological 2-groups. We explain various viewpoints on topological 2-groups and the Čech cohomology $H^1(M, \mathbf{G})$ with coefficients in a topological 2-group $\mathbf{G}$, also known as "nonabelian cohomology". Then we sketch a proof that under mild conditions on M and $\mathbf{G}$ there is a bijection between $H^1(M, \mathbf{G})$ and $[M, B|\mathbf{G}|]$, where $B|\mathbf{G}|$ is the classifying space of the geometric realization of the nerve of $\mathbf{G}$. (Received September 08, 2008)

1046-55-617 **Andrew W. Elliott*** (elflord@rice.edu), Math Department – MS 136, Rice University, 6100 S. Main St., Houston, TX 77005. *Construction of H-thick knots in Khovanov Homology.* Preliminary report.

Using Jacobsson homomorphisms and Lee's spectral sequence, we describe a general procedure, quasipositive modification, for constructing knots of thickness at least 3 in rational Khovanov homology. Moreover, we show that a specific family of such knots cannot be detected by Khovanov's thickness criteria. (Received September 09, 2008)

1046-55-655 **A. Bahri** and **M. Bendersky*** (mbenders@hunter.cuny.edu), Dept. of Mathematics and Statistics, Hunter College, 695 Park Ave., New York, NY 10065, and **F. Cohen** and **S. Gitler**. *Stable splitting of Generalized Moment-Angle Complexes.*

Toric varieties are an important family of spaces occurring in algebraic geometry and topology. In their seminal paper, Davis and Januszkiewicz define the moment-angle complex associated to a toric variety which in turn is associated to a simplicial complex. It was then generalized by Strickland. The cohomology of the generalized moment-angle complex was computed by Goresky and MacPherson in terms of the underlying simplicial complex. In joint work with A. Bahri, F. Cohen and S. Gitler we show that the generalized moment angle complex stably splits into pieces corresponding to the Goresky MacPherson theorem. As a consequence there is an analogous splitting for an arbitrary generalized homology theory. (Received September 09, 2008)

1046-55-799 **Armira Shkembi*** (armira@wayne.edu), 2440 Jonathan Drive, Sterling Heights, MI 48310. *Some Ext groups in motivic cohomology theory.*

The talk focuses on motivic cohomology and some computational results on *Ext* groups over a subalgebra of the motivic steenrod algebra. Through out it we work with motivic F_2-cohomology over $SpecC$. We give a brief introduction to $A(1)$, a subalgebra of the motivic Steenrod algebra. We then compute $Ext^*_{A(1)}(H^{*,*}(pt), H^{*,*}(pt))$ as a ring and $Ext^*_{A(1)}(H^{*,*}(DQ_\infty), H^{*,*}(pt))$ as a module over $Ext^*_{A(1)}(H^{*,*}(pt), H^{*,*}(pt))$, where DQ_∞ is a motivic object which will be introduced during the talk. (Received September 11, 2008)

1046-55-807 **Daniel A Ramras*** (dan.ramras@vanderbilt.edu), 1326 Stevenson Center, Department of Mathematics, Vanderbilt University, Nashville, TN 94305. *New developments in the topology of representation spaces.*

In recent years, progress has been made from a number of directions in understanding the topology of representation spaces associated to infinite discrete groups. I will describe a homotopy theoretical method, based on Carlsson's notion of deformation K-theory, for studying these spaces after stabilization. This method relies heavily on work of Tyler Lawson and has produced concrete results in a variety of cases, including fundamental groups of surfaces and related spaces. I'll also describe some conjectures relating these spaces to topological K-theory. These conjectures closely resemble well-known results and conjectures in topological and algebraic K-theory.

There has also been progress in studying representation spaces before stabilization. In particular, I'll discuss Morse theoretical methods introduced by Ho and Liu, which have produced cohomological information about the representation spaces of non-orientable surface groups. (Received September 11, 2008)

1046-55-916 **Peter Bubenik*** (p.bubenik@csuohio.edu), Department of Mathematics, Cleveland State University, 2121 Euclid Ave. RT 1515, Cleveland, OH 44115, and **Gunnar Carlsson**, **Peter T. Kim** and **Zhiming Luo**. *Estimating the topology of functions on manifolds from noisy samples.*

We estimate the persistent homology of sublevel sets of a function on a compact Riemannian manifold, from a finite noisy sample. The Stability Theorem of Cohen-Steiner, Edelsbrunner and Harer bounds the distance between the persistent homologies of the sublevel sets of two functions by the supremum norm of the difference between the two functions. This allows us to convert our topological problem to the statistical nonparametric regression problem on a compact manifold under the sup-norm loss. We calculate the sharp asymptotic minimax bound. Furthermore, the construction of the estimator in the proof is well-suited to calculations of the persistent homology of its sublevel sets. (Received September 12, 2008)

1046-55-1008 **Edgar J Lobaton*** (lobaton@eecs.berkeley.edu), 1089 57th St Apt 2, Emeryville, CA 94608. *Recovering Topology of a Camera Networ Coverage.* Preliminary report.

Camera networks are used for surveillance, monitoring and tracking. For the most part, localization information such as camera locations and other environmental factors (e.g. walls, rooms, and building layout) are known. But, how much of this information is really necessary to perform any of these tasks? The present work focuses on tracking and navigation tasks that do not require full localization information. In particular, we will discuss the recovery of topological information of a camera network coverage, captured in a Simplicial representation built from discrete observations, and used for tracking, identification of homotopic paths, and navigation. A simple algorithm for obtaining this discrete observations and building the Simplicial representation will demonstrate how these tasks can be performed without full localization information. This algorithm will prove to be particularly useful for ad-hoc camera networks with limited computational power and energy. (Received September 13, 2008)

1046-55-1248 **Rekha Santhanam*** (santhana@math.jhu.edu), 404 Kreiger Hall, 3400 N. Charles Street, Baltimore, MD 21218. *Defining the units of equivariant ring spectra.*

Recent work of Freed, Hopkins and Teleman relates twisted equivariant K-theory of a compact lie group with the Verlinde algebra. This has generated considerable interest in twisted (equivariant) cohomology theories.

The twists of a cohomology ring theory are parametrized by the classifying space of its multiplicative units. Similarly, we expect the twists of an equivariant cohomology ring theory to be parametrized by the classifying space of its multiplicative units. We develop the framework for defining the units of equivariant cohomology ring theories when the group acting is finite.

The category of E_∞-spaces and the category of Γ-spaces both model connective spectra. May and Thomason gave a comparison of these models and showed that they are equivalent. We show that the category of equivariant Γ-spaces and the category of equivariant E_∞-spaces are Quillen equivalent with appropriate model category structures. We then construct the units of equivariant E_∞-ring spectra in terms of equivariant Γ-spaces. (Received September 15, 2008)

1046-55-1436 **Paul Thomas Pearson*** (paul.pearson@rochester.edu), University of Rochester, Department of Mathematics, RC Box 270138, Rochester, NY 14627. *The homology of topological modular forms.*

We describe the mod 2 homology of the spaces in the spectrum of topological modular forms (tmf). This homology has an unstable part coming from the homology of the spaces in the sphere spectrum, and a stable part coming from the homology of the spectrum tmf. (Received September 15, 2008)

1046-55-1513 **Maia Averett***, Mathematics and Computer Science Department, Mills College, 5000 MacArthur Blvd, Oakland, CA 94613. *Completion of real Johnson-Wilson theory $E(n)$ yields fixed points of Morava E-theory.*

Complex conjugation gives rise to an involution on complex cobordism and hence on Johnson-Wilson theory $E(n)$. This involution extends to the completion $\widehat{E(n)} = E(n)^{\wedge}_{I_n}$, which by work of Goerss, Hopkins, and Miller supports an action of the Morava stabilizer group S_n. In particular, the subgroup of S_n generated by the formal inverse provides an involution on $\widehat{E(n)}$, so it is natural to ask if these two involutions have the same homotopy fixed points. We answer this question affirmatively and as a corollary we obtain that Kitchloo and Wilson's real Johnson-Wilson theory is a commutative S-algebra. (Received September 15, 2008)

1046-55-1554 **yuliy baryshnikov***, 600 mountain avenue, murray hill, NJ 07974. *Counting objects in dense sensor networks: a topological integral transform.* Preliminary report.

Information fusion in dense, redundant sensor networks with nodes of low power and intelligence is one of the major problems in the theory of distributed sensing. Even the simple task of determining the number of the objects in the supervised domain becomes nontrivial given the intrinsic overcounting of the objects.

We approach this question of target counting from a topological perspective, reducing the task to a problem of integral calculus with respect to Euler characteristic. The solution we (this is joint work with Robert Ghrist, UPenn) proposed earlier failed to address the situation when the targets' footprints have vanishing Euler characteristic (as, e.g., in the important case of annuli). In this talk I will outline some new results addressing this case. (Received September 16, 2008)

1046-55-1595 **Michael A. Hill*** (mikehill@virginia.edu), University of Virginia, Department of Mathematics, PO Box 400137, Charlottesville, VA 22904, and **Michael J. Hopkins** and **Douglas C. Ravenel**. *Differentials in homotopy fixed point spectral sequences.*

We describe geometric techniques that can be used to easily produce canonical families of differentials in homotopy fixed point spectral sequences for highly structured ring spectra. The primary application is to the higher real K-theories of Hopkins and Miller, defined as the homotopy fixed points of finite subgroups of the Morava stabilizer group acting on the Lubin-Tate spectrum. There are also applications to topological cyclic homology, providing some clean arguments for differentials therein. (Received September 16, 2008)

1046-55-1697 **Mark H. Meilstrup*** (mark@math.byu.edu), BYU Mathematics Deptartment, 292 TMCB, Provo, UT 84602, and **Gregory R. Conner**, BYU Mathematics Department, 292 TMCB, Provo, UT 84602. *Homotopy Invariants for One-Dimensional and Planar Spaces.*

We discuss homotopy invariants of one-dimensional and planar spaces. Since the late 90's there has been significant interest in this area. This work is related to that of Cannon, Conner, Eda, Kawamura, Zastrow and others. These topologically defined invariants can be determined algebraically. In particular, for some very wild spaces (not locally simply connected), the fundamental group is sufficient to determine the homotopy type of the space. For example, the Hawaiian Earring, the Sierpinski curve, and the Menger curve can all be differentiated by their fundamental groups. (Received September 16, 2008)

1046-55-1734 **Jane H Long*** (longjh@sfasu.edu), Department of Mathematics and Statistics, Box 13040 - SFA Station, Nacogdoches, TX 75962. *The Cohomology of $PSL(3,p)$, p an odd prime.* Preliminary report.

We discuss methods for computing the cohomology of $PSL(3,p)$, p an odd prime, in the characteristic p. (Received September 16, 2008)

1046-55-1845 **Valentina Joukhovitski*** (valya@umich.edu), Department of Mathematics, University of Michigan, 530 Church Street, Ann Arbor, MI 48109. *Level structures, Igusa tower and topological modular forms.*

Level structures have been around for quite a while. These appeared in arithmetic number theory and were heavily studied by number theorists some time ago. In homotopy theory level structures were used Matthew Ando to construct power operations om MU. We will fuse homotopy theory with arithmetic number theory by constructing a spectrum of topological modular forms with level structures. despite the well known nature of level structures in number theory, transition to homotopy theory is far from being smooth.

The aim of the presentation is to introduce construction of topological modular forms with specific level structures, $tmf(p^n)$ and discuss the motivation for the study of such an object. (Received September 16, 2008)

1046-55-1893 **Aaron C Leeman*** (aleeman@uoregon.edu), 1420 Villard St. #111, Eugene, OR 97403. *Generating spaces for $S(n)$-acyclics.* Preliminary report.

In *Cellular Spaces, Null Spaces and Homotopy Localization*, Dror Farjoun proves that rationally acyclic, simply connected spaces are built out of a wedge of mod-p Moore spaces. He also proves that simply connected spaces which are acyclic with respect to mod-p K-theory have suspensions that are built out of V(1), the cofiber of the Adams' map $v_1 : M^{q+3}(p) \to M^3(p)$, p an odd prime. This notion of one space being "built out of" another space can be made precise, but should be thought of as analogous to CW-complexes being built out S^1.

I'll discuss a generalization of this result, mentioned by Dror Farjoun in the above book, where sufficiently connected spaces which are acyclic with respect to a homology theory called $S(n)$ have suspensions that are built out of a space we call $W(n)$, where $W(n)$ is an appropriately chosen type $n+1$ finite space. If the telescope conjecture is true, $S(n)$ can be taken to be the Johnson-Wilson theory $E(n)$. If it fails, $S(n)$ is a replacement for the theory $E(n)$ which has the same finite acyclic spectra. (Received September 16, 2008)

1046-55-2033 **Adeniran Adeboye*** (aadeboye@howard.edu), Department of Mathematics, Howard University, Washington, DC 20059. *A (Co-)Homology Invariant of Topological Manifolds and its Interface with Boundary Value Problems in Riemannian Geometry.* Preliminary report.

Let N be a closed n-dimensional topological manifold and let $b_k(N)$ stand for the k-th Betti number of N . We define an invariant

$$A(N) = \sum_{k=0}^{n} k b_k(N)$$

Whereas when n is even A(N) is just $\frac{n}{2}\chi(N)$, for n odd, A(N) is actually a global invariant which is non-zero in general. In this talk, we compute A(N) for certain spaces and illustrate some of its properties. For manifolds M with boundary N, the invariant is also defined with each of absolute and relative (co-)homologies. When M is an even dimensional Riemannian manifold with boundary N, we show an interesting linkage between the Euler characteristics of M obtained from differential forms satisfying the Neumann and Dirichlet conditions on N and the value of A(N). (Received September 16, 2008)

1046-55-2092 **Jack Morava*** (jack@math.jhu.edu). *Extensions of motives and cell bundles.*

Abstract: Algebraic geometers are interested in a category of mixed Tate modules over $\mathbb{Z}$, in which extensions of cell-like objects are classified by elements of certain algebraic K-groups of the integers (at least, after tensoring with the rationals). On the other hand, Waldhausen has shown that certain cell bundles are also (rationally) classified by similar K-groups. It would be nice if there were a differential-topological interpretation of motives which accounts for this near coincidence, but there is a small dimensional discrepancy in the groups which occur... (Received September 17, 2008)

1046-55-2105 **Barry John Walker***, 415 Howard Street, Apartmnent 713, Evnaston, IL 60202.
Orientations and p-adic Analysis.

Producing operations in Lubin-Tate cohomology theories via finite subgroups of a universal deformation has been fruitful. For example, Ando, Hopkins and Strickland have used this approach to show that the sigma orientation for elliptic spectra is an H_∞ map. More generally, they were able to classify all orientations of this type for elliptic spectra via formal group data.

In more recent work, Ando, Blumberg, Gepner, Hopkins and Rezk have shown that the sigma orientation factors though an E_∞ map whose target is the connective version of topological modular forms. This result follows from their classification of such morphisms. This stronger result involves families of modular forms that enjoy Kummer type congruences.

All of these methods apply to complex K-Theory. For the height one situation, the sequence of modular forms is replaced by a sequence of rationals. In this talk we will use the language of p-adic analysis and work of N. Katz to show that any H_∞ orientation for p-adic K-Theory is an E_∞ map. (Received September 17, 2008)

1046-55-2129 **Shmuel Weinberger*** (Shweinberger@gmail.com), University of Chicago, Department of Mathematics, 5734 S. University Ave., Chicago, IL 60637-1514. *Homological Methods for the study of Data Sets*

A number of groups have been using homological techniques to get information about data sets that seem to have geometric structure or origin. In this talk, based substantially on joint work with P.Niyogi and S.Smale, and with Y.Baryshnikov, I will discuss theoretical bases for such methods and information about the sample complexity of these problems (Received September 29, 2008)

57 ► Manifolds and cell complexes

1046-57-56 **Sungmo Kang*** (skang@math.utexas.edu), Department of Mathematics, 1 University Station C1200, Austin, TX 78712. *Reducible and toroidal Dehn filling with distance 3.*

If a hyperbolic 3-manifold admits a reducible and a toroidal Dehn filling, the distance between the filling slopes is known to be bounded by three. The first example of such a manifold realizing the distance 3 was given by Boyer and Zhang by using the Whitehead link. Using "Tangles", Eudave-Muñoz and Wu gave infinite family of hyperbolic manifolds admitting the above two Dehn fillings. In this talk, I show that these are all hyperbolic manifolds which admit a reducible Dehn filling and a toroidal Dehn filling with distance 3. (Received July 16, 2008)

1046-57-64 **Brandy J Guntel*** (bguntel@math.utexas.edu), Departmentment of Mathematics, 1 University Station C1200, Austin, TX 78712. *Dean Knots.*

Let K be a curve lying on the boundary of the genus 2 handlebody H and denote by $H[K]$ the manifold obtained by adding a 2-handle to H along K. We call K primitive with respect to H if $H[K]$ is a solid torus and Seifert with respect to H if $H[K]$ is a Seifert fiber space. Now let K be a knot lying in a genus 2 Heegaard surface F of S^3, with F bounding the handlebodies H and H'. We call K a Dean knot if it is primitive with respect to H and Seifert with respect to H'. In this talk, we will discuss some properties of Dean knots. (Received July 18, 2008)

1046-57-130 **Charles Frohman*** (frohman@math.uiowa.edu), Department of Mathematics, The University of Iowa, Iowa City, IA 52242, and **Kania-Bartoszynska** (jkaniaba@nsf.gov), 4201 Wilson Boulevard, Arlington, VA 22230. *Natural Volumes on Character Varieties of Three-Manifolds.*

We will discuss the relationship between Natural Volumes on Character Varities, Reidemeister Torsion, and Quantum Invariants. After an explanation of how to induce volume forms we discuss different formulas for them coming from a local-global principle. We will finally look at some examples of the volumes for knots and three-manifolds. (Received July 31, 2008)

1046-57-131 **Charles Frohman*** (frohman@math.uiowa.edu), The Department of Mathematics, The University of Iowa, Iowa City, IA 52242. *Embedded Khovanov Homology and Skein Modules of Three Manifolds.*

I will give an overview of progress along these lines including work of Adam McDougal on a diagramless Khovanov homology, Heather Russell on skein modules and the the Springer action, Jeff Boerner's work on homology theories for links in surface bundles, Uwe Kaiser's work on skein modules associated to Frobenius algebras, and my own work.

The heart of the idea is that quantum invariants seem to be more about embedded surfaces in three manifolds rather than about links. We will see how the idea of TQFT in dimension 1+1 leads you to studying incompressible surfaces, and see how relatoins between incompressible surfaces reflect the topology of the manifold. (Received July 31, 2008)

1046-57-139 **David C Bachman*** (bachman@pitzer.edu), 1050 N. Mills Ave, Claremont, CA 91711. *Topological index theory for isotopy classes of surfaces.*

We introduce several notions of topological index for isotopy classes of surfaces in a 3-manifold. Each mimics the index of a minimal surface, in the sense that surprisingly analogous results hold. Applications include theorems about isotopy and stabilization of Heegaard splittings in the presence of topological barrier surfaces, such as those that arise in "sufficiently complicated" amalgamations. (Received August 05, 2008)

1046-57-197 **Emily Peters*** (eep@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, 970 Evans Hall, Berkeley, CA 94720, and **Scott Morrison** and **Noah Snyder**. *Planar Algebras and knots.* Preliminary report.

Planar algebras are algebras which have an action by certain kinds of planar pictures. Knot diagrams are an example of a planar algebra, and a planar algebra homomorphism from knot diagrams to the Temperley-Lieb algebra gives rise to the Jones polynomial. Homomorphisms to other planar algebras give different knot invariants. I will show how to construct these invariants, and prove some interesting identities among colored Jones polynomials. (Received August 18, 2008)

1046-57-202 **Tao Li*** (taoli@bc.edu), Department of Mathematics, Boston College, Chestnut Hill, MA 02467. *Heegaard surfaces and the distance of amalgamation.*

Let M_1 and M_2 be orientable irreducible 3–manifolds with connected boundary and suppose $\partial M_1 \cong \partial M_2$. Let M be a closed 3–manifold obtained by gluing M_1 to M_2 along the boundary. We show that if the gluing homeomorphism is sufficiently complicated, then M is not homeomorphic to S^3 and all small-genus Heegaard splittings of M are standard in a certain sense. In particular, $g(M) = g(M_1) + g(M_2) - g(\partial M_i)$, where $g(M)$ denotes the Heegaard genus of M. This theorem can also be extended to manifolds with multiple boundary components. (Received August 18, 2008)

1046-57-286 **Shari K. Ultman*** (ultmans@science.oregonstate.edu), 722 NW 33rd Street, Corvallis, OR 97330. *Cohomology of cohomogeneity-one manifolds.*

A smooth action by a compact Lie group G on a closed, connected manifold M is *cohomogeneity-one* if the orbit space M/G is one-dimensional. If M/G is diffeomorphic to a closed interval, then M is diffeomorphic to the union of two disk bundles glued together over a common boundary. We illustrate how this decomposition of M into bundles relates to the cohomology ring $H^*(M;\mathbb{Z})$. (Received September 16, 2008)

1046-57-293 **Vladimir Turaev*** (vtouraev@indiana.edu). *Certain enumeration problems in 2-dimensional topology.*

We shall discuss a solution to several enumeration problems in the topology of surfaces following my preprint arXiv:0804.1489. A classical theorem of Frobenius and Mednykh counts the number of homomorphisms of the fundamental group of a closed orientable surface to any finite group. This theorem generalizes to an enumeration of homotopy classes of sections of a locally trivial fiber bundle over the surface. In particular, this provides a necessary and sufficient homological condition for the existence of such a section. These results relate topology of surfaces to the theory of projective representations of finite groups. The proofs are based on methods of Topological Quantum Field Theory. (Received August 25, 2008)

1046-57-304 **Heather M. Russell*** (hrussell@math.uiowa.edu), University of Iowa Department of Mathematics, 15 MacLean Hall, Iowa City, IA 52242-1419, and **Julianna S. Tymoczko** (tymoczko@math.uiowa.edu), University of Iowa Department of Mathematics, 15 MacLean Hall, Iowa City, IA 52242-1419. *A geometric and combinatorial construction of the Springer representation.*

Springer varieties are subvarieties of the flag variety whose cohomology carries a representation of the symmetric group. Using Khovanov's construction of a family of Springer varieties X_{2n}, we apply topological techniques to obtain an explicit combinatorial definition of the Springer action on X_{2n}. We use this formulation to identify the Springer representations in *every* homology degree, proving the Springer representation on $H_k(X_{2n})$ is the irreducible representation corresponding to the partition $(2n-k,k)$. (Received September 15, 2008)

1046-57-309 **Zhixu Su*** (zhisu@indiana.edu), Department of Mathematics, Indiana University, Bloomington, IN 47405. *A 32 dimensional manifold which is a rational analog of the projective plane.* Preliminary report.

There are 4 kinds of projective planes: real, complex, quaternionic, and octonionic. No such projective plane exists in dimension 32, due to the nonexistence of a Hopf invariant 1 map. However, using local surgery theory, I showed there does exist a rational analog: a smooth manifold whose rational homology is rank 1 in dimension 0, 16, and 32, and is zero otherwise. Local surgery theory reduced the question to finding possible Pontryagin classes satisfying a set of congruence relations provided by Riemann-Roch integrality theorem. (Received August 25, 2008)

1046-57-390 **Hossein Namazi*** (hossein@math.utexas.edu), Department of Mathematics, 1 University Station C1200, Austin, TX 78712. *Geometry of splittings and models.*

We discuss an approach in relating the topology and geometry of the three manifolds that uses the combinatorics of Heegaard splittings. (Received August 29, 2008)

1046-57-521 **Angela Angeleska**, **Natasa Jonoska** and **Masahico Saito*** (saito@math.usf.edu). *Knot theoretical methods for RNA-template guided DNA recombinations.*

RNA-template guided DNA recombinations are modeled by DNA molecules form spatial 4-valent graphs, with rigid vertices representing recombination sites. We propose using methods in knot theory to investigate properties of such graphs, that are of interest from a biological point of view. A polygonal Hamiltonian path, for example, represents a resulting DNA sequence after recombinations, and defines smoothings similar to the ones for virtual knot diagrams colored by two colors as studied by Kauffman. Relations and differences of these two types of smoothings are discussed, through problems motivated from biology and methods used in knot theory. (Received September 05, 2008)

1046-57-552 **Steven D Wallace*** (steven.wallace@maconstate.edu), Macon, GA 31206. *Surgery equivalence invariants of generalized colored knots.*

The pair (K,r) consisting of a knot K and a surjective representation of the knot group onto a dihedral group is said to be a colored knot. The equivalence of colored knots up to surgery by unknots in the kernel of r has been studied most recently by D. Moskovich and A. Kricker. We extend previous results by R.A. Litherland and the author to knots with knot group representations onto other types of groups. More precisely, we modify some three-manifold bordism invariants developed by T. Cochran, A. Gerges, and K. Orr, to define complete invariants of the surgery equivalence classes of generalized colored knots. (Received September 07, 2008)

1046-57-602 **David A Clark*** (davidclark@rmc.edu), Randolph-Macon College, P.O. Box 5005, Ashland, VA 23005. *Functoriality for the $\mathfrak{su}_3$ Khovanov homology.* Preliminary report.

We prove that Morrison and Nieh's categorification of the $\mathfrak{su}_3$ quantum knot invariant is functorial with respect to tangle cobordisms. This is in contrast to the categorified $\mathfrak{su}_2$ theory, which was not functorial as originally defined. We use methods of Bar-Natan to construct explicit chain maps for each variation of the third Reidemeister move. Then, to show functoriality, we modify arguments used by Clark, Morrison, and Walker to show that induced chain maps are invariant under Carter and Saito's movie moves. (Received September 08, 2008)

1046-57-616 **Angela L Pile*** (apile@lhup.edu), Math Department, 418 Robinson Hall, Lock Haven University, Lock Haven, PA 17745. *The Space of Regular Polygons.*

We will analyze the space of regular polygonal knots with six or fewer edges, that is, polygonal knots with the requirements that the lengths of the edges and the measures of the interior angles are equal. We will find that the space of regular hexagons has thirteen components, all of which contain topological unknots. However, the hexagons in twelve of the components are geometrically knotted because they cannot be deformed to the standard regular planar hexagon. (Received September 09, 2008)

1046-57-622 **Lenny Ng*** (ng@math.duke.edu), Mathematics Department, Duke University, Box 90320, Durham, NC 27708. *Transverse knots and knot homologies.*

Over the last few years, knot homologies have produced surprising applications to the study of transverse knots in contact geometry and braid theory. We give a survey update on recent results in this direction. (Received September 09, 2008)

1046-57-626 **Jonathan A Hillman** (jonh@maths.usyd.edu.au), Sydney, NSW 2006, Australia, **Daniel S Silver*** (silver@jaguar1.usouthal.edu), ILB 325, Mobile, AL 36688, and **Susan G Williams** (swilliam@jaguar1.usouthal.edu), Mobile, AL 36688. *Twisted Blanchfield Pairings.*

Given a symplectic $SL_{2n}\mathbb{C}$-representation γ of the group π of a knot k, there is an associated twisted Blanchfield pairing of the first twisted homology module $H_1(X(k);\gamma)$. Consequently, the homology has the form $A \oplus \bar{A}$ (where $^-$ denotes the same module with conjugate $\mathbb{Z}[t^{\pm 1}]$-structure induced by $t \mapsto t^{-1}$) and the twisted Alexander polynomial $\Delta_\gamma(t)$ has the form $f(t)f(t^{-1})$. Using previous work, we see that when $\gamma : \pi \to SL_2\mathbb{C}$ is a nonabelian parabolic representation of the group of a 2-bridge knot, $\Delta_\gamma(-1)/\Delta_\gamma(1)$ is a square. This confirms a conjecture of the second and third authors, previously proven in a special case by M. Hirasawa and K. Murasugi. (Received September 09, 2008)

1046-57-638 **Paul R Turner*** (paul@ma.hw.ac.uk), Departement de mathematiques, Universite de Fribourg, Chemin du Musee 23, CH-1700 Fribourg, Switzerland, and **Brent J Everitt**. *Sheaves of modules over posets and Khovanov homology.*

The decorated hypercube found in the construction of many link homology theories is an example of a sheaf of modules over a Boolean lattice. There is a well developed theory of sheaves over small categories and in this talk we will outline some implications of this point of view to Khovanov homology. (Received September 09, 2008)

1046-57-675 **Cameron McA Gordon*** (gordon@math.utexas.edu), Department of Mathematics, University of Texas, 1 University Station C1200, Austin, TX 78712, and **Henry Wilton**. *Surface subgroups of doubles of free groups.*

A well-known question of Gromov asks whether every one-ended word-hyperbolic group G contains a surface subgroup. We consider the case where G is the double of a free group F along the cyclic subgroup generated by an element w in F, and give various conditions on w under which Gromov's question has an affirmative answer. (Received September 09, 2008)

1046-57-676 **Philip J.P. Ording*** (pording@mec.cuny.edu), Department of Mathematics, Medgar Evers College, 1150 Carroll Street, Brooklyn, NY 11205. *On knot Floer homology of satellite* $(1,1)$ *knots.*

A $(1,1)$ knot is a knot $K \subset S^3$ which intersects each solid torus H_i, $i = 1,2$, of a genus one Heegaard splitting $S^3 = H_1 \cup H_2$ in a single trivial arc. Goda, Matsuda and Morifuji recognized that K is a $(1,1)$ knot if and only if it admits a doubly pointed Heegaard diagram of genus one, as defined by Ozsváth and Szabó. In this case, Ozsváth and Szabó have shown that the knot Floer homology of K admits a particularily direct combinatorial calculation. This talk will present a complementary algorithm for producing a doubly pointed Heegaard diagram from a given $(1,1)$ knot and then discuss its application in the study of knot Floer homology of certain satellite knots with trefoil companions. (Received September 09, 2008)

1046-57-752 **William M Goldman**, **Greg McShane**, **George Stantchev** and **Ser P Tan*** (mattansp@nus.edu.sg), Department of Mathematics, National University of Singapore, 2, Science Drive 2, Singapore, 117543, Singapore. *Dynamics of the modular group action on certain character varieties of the two generator free group.*

The automorphisms of a two-generator free group π acting on the space of orientation-preserving isometric actions of π on hyperbolic 3-space defines a dynamical system. Those actions which preserve a hyperbolic plane but not an orientation on that plane is an invariant subsystem, which reduces to an action of a group Γ on $\mathbb{R}^3$ by polynomial automorphisms preserving the cubic polynomial $k(x,y,z) := -x^2 - y^2 + z^2 + xyz - 2$. The Fricke space of marked hyperbolic structures on the 2-holed projective plane with geodesic boundary or cusps identifies with the subset $\Omega(C_{0,2}) \subset \mathbb{R}^3$ defined by $z \le -2$ and $xy + z \ge 2$. The generalized Fricke space of marked hyperbolic structures on the 1-holed Klein bottle with a geodesic boundary, cusp, or cone point identifies with the subset $\Omega(C_{1,1}) \subset \mathbb{R}^3$ defined by $z > 2$ and $xyz \ge x^2 + y^2$. We show that Γ acts properly on the subsets $\Gamma \cdot \Omega(C_{0,2})$ and $\Gamma \cdot \Omega(C_{1,1})$. Furthermore for each $k_0 \in \mathbb{R}$, the action of Γ is ergodic on the complement of $\Gamma \cdot \Omega(C_{0,2})$ in $k^{-1}(k_0)$ for $k_0 < 2$. The complement of $\Gamma \cdot \Omega(C_{1,1})$ in $k^{-1}(k_0)$ for $k_0 > 2$ has empty interior. (Received September 10, 2008)

1046-57-825 **Jesse E Johnson*** (jessee.johnson@yale.edu), Yale University, Mathematics Department, PO Box 208283, New Haven, CT 06520. *A normal surface calculus for Heegaard splittings.*

A normal or almost normal surface is a surface embedded in a 3-manifold so that it intersects a triangulation in a locally simple way that can easily be encoded by a computer program. Rubinstein and Stocking showed that every strongly irreducible Heegaard can be made almost normal with respect to a nice enough triangulation for the ambient 3-manifold. I will describe an algorithm that determines which almost normal surfaces are Heegaard surfaces and identifies pairs of isotopic surfaces. (Received September 11, 2008)

1046-57-839 **Louis H. Kauffman***, Math UIC, 851 South Morgan Street, Chicago, IL 60607-7045.
Oriented State Sums for the Jones Polynomial.

For classical knots and links the Jones polynomial is only mildly sensitive to orientation. This is reflected in the fact that the bracket state sum model for the Jones polynomial is defined on unoriented diagrams. (The orientation dependence derives from the writhe normalization of the bracket state sum.) However, if one makes an oriented analog of the bracket state sum, one finds that there are a number of ways to keep orientation information locally in the state summation and to, in principle, add infinitely many new variables. Curiously, for classical knots in the three-sphere all this information disappears due to the Jordan Curve Theorem. This is not the case for knots in thickened surfaces and for virtual knots, and there are very strong and non-trivial oriented state sum generalizations of the Jones polynomial in these domains. This talk will discuss such generalizations. (Received September 12, 2008)

1046-57-925 **Scott Morrison*** (scott@tqft.net). *Blob homology.*

We define the "blob complex" $B_*(M, C)$ associated to an n-manifold M and a (suitable) n-category C. This is a simultaneous generalisation of two interesting gadgets. When $n = 1$, $M = S^1$ and C is an algebra, the homology of the blob complex is the Hochschild homology of the algebra. On the other hand, the zero-th homology of the blob complex is the usual skein module of "pictures from C drawn on M". In this sense the blob complex is a "derived" variant of a TQFT.

I'll give the definition, and explain a few important properties. We hope to apply blob homology to tight contact structures (for $n = 3$) and Khovanov homology (for $n = 4$). In both theories exact triangles play an important role. These exact triangles don't interact well with the gluing structure of the associated TQFTs, however. Our motivation for considering blob homology is to work around these difficulties. (Received September 12, 2008)

1046-57-932 **Martin Scharlemann** (mgscharl@math.ucsb.edu), Department of Mathematics, UC Santa Barbara, Santa Barbara, CA 93106, and **Abigail Thompson*** (thompson@math.ucdavis.edu), Department of Mathematics, UC Davis, Davis, CA 95616.
Surgery on a knot in (surface)x(I).

We examine under what conditions surgery on a knot in a (surface)x(I) yields a manifold with compressible boundary. (Received September 12, 2008)

1046-57-960 **Michael Eisermann*** (Michael.Eisermann@ujf-grenoble.fr), Institut Fourier, Universite Grenoble 1, 100 rue des Maths, BP 74, 38402 St Martin d'Heres, France. *Set-theoretic Yang-Baxter operators and their deformations.*

Yang-Baxter operators have played a prominent role in knot theory and low-dimensional topology ever since the discovery of the Jones polynomial in 1984. Attempts to systematically construct and understand solutions of the Yang-Baxter equation have led to the theory of quantum groups.

In this talk we consider the special case of set-theoretic solutions and study their deformations within the space of Yang-Baxter operators over some complete ring, a problem initiated by Freyd and Yetter in 1989. We survey some past results and present recent progress in the classification of such deformations. The picture is by now reasonably complete for operators derived from conjugation in a group, or more generally from quandles or racks. We also indicate some open questions in the case of biquandles or biracks. (Received September 13, 2008)

1046-57-969 **Liam Watson*** (liam.watson@cirget.ca), Departement de mathematiques, UQAM, C.P. 8888, Succursale Centre-ville, Montreal, Quebec H2V2P4, Canada. *Involutions on 3-manifolds and Khovanov homology.*

Given a 3-manifold with torus boundary, together with an appropriate involution, there is a natural two-fold branched cover of the 3-sphere obtained by filling the boundary with a solid torus. This talk will illustrate a relationship between the geometry of the filled manifold and the Khovanov homology of the branch set. (Received September 13, 2008)

1046-57-1010 **Alexander Fel'shtyn*** (felshtyn@diamond.boisestate.edu), 1910 University Drive, Boise, ID 83725-1555. *How to categorify dynamical zeta functions.* Preliminary report.

A programm of a categorification a la Khovanov of Weil type dynamical zeta functions is proposed.

Theorem Let $\phi : \Sigma \to \Sigma$ be a symplectomorphism of a compact surface. Then the Weil zeta function is a graded Euler characteristic

$$L_\phi(z) := \exp\left(\sum_{n=1}^{\infty} \frac{L(\phi^n)}{n} z^n\right) = \sum_{d=0}^{\infty} L(S^d(\phi))z^d = \sum_{d=0}^{\infty} \chi(\phi, d)z^d = \chi(\phi, z),$$

where $L(\phi^n), L(S^d(\phi))$ are Lefschetz numbers, $S^d(\phi) : S^d(\Sigma) \to S^d(\Sigma)$ is induced map on d-fold symmetric power of Σ and

$$\chi(\phi, d) = \chi(PFH(\phi, d)) = \chi(ECH(T_\phi, s_d)) = \chi(SWF(T_\phi, s_d)) = \chi(HF^+(T_\phi, s_d))$$

is the Euler characteristic of the periodic Floer homology of degree d or of the embedded contact homology of the mapping torus T_ϕ for $Spin^c$-structure s_d, or the Euler characteristic of the corresponding Seiberg-Witten-Floer or Ozsvath-Szabo homology of (T_ϕ, s_d))

There is a strong indication that $SWF(T_\phi, s_d)$ cohomology provide a categorification of the Nielsen periodic point theory and corresponding minimal zeta function.

There are intriguing questions about categorification of arithmetic zeta functions. (Received September 15, 2008)

1046-57-1025 **Carmen L Caprau*** (ccaprau@csufresno.edu), Department of Mathematics, 5245 North Backer Avenue M/S PB108, Fresno, CA 93740. *Twin TQFTs and Frobenius algebras.*

We study the category of *singular 2-cobordisms* (these are 2-dimensional cobordisms with seams) and give a description of it in terms of generators and relations. We also introduce a special sort of 2-dimensional "twin" Topological Quantum Field Theories (TQFTs). A twin TQFT is defined on singular 2-cobordisms, and is equivalent (as a symmetric monoidal category) to a "twin Frobenius algebra" in a monoidal category. A twin Frobenius algebra (C, W, z, z^*) consists of two commutative Frobenius algebras C and W, and an algebra homomorphism $z : C \to W$ with dual $z^* : W \to C$, subject to some conditions. It follows that the category of singular 2-cobordisms admits an algebraic description as the free monoidal category on a twin Frobenius algebra.

The category of singular 2-cobordisms has strong connections to the $sl(2)$ link cohomology via webs and foams modulo local relations. (Received September 13, 2008)

1046-57-1026 **Nicolai Reshetikhin*** (reshetik@Math.Berkeley.EDU). *Invariants of links with flat connections in the complement.*

Quantum groups at roots of unity with large center can be used to construct invariants of links in S^3 with flat connections in a trivial G-bundle over the complement to the link. It is interesting that similar structures are involved in the Chiral Potts model in statistical mechanics. The talk will focus on invariants of links and their properties. (Received September 13, 2008)

1046-57-1191 **William M. Goldman*** (wmg@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742, and **Eugene Z. Xia** (ezxia@ncku.edu.tw), Division of Mathematics, National Center for Theoretical Science, National Cheng-Kung University, Tainan 701, Taiwan. *Ergodicity of subgroups of mapping class groups on* $\mathsf{SU}(2)$*-character varieties.*

Let Σ be a compact oriented surface with fundamental group π. Its mapping class group $\Gamma := \mathsf{Mod}(\Sigma)$ acts on the character varieties $X := \mathsf{Hom}(\pi, \mathsf{SU}(2))/\mathsf{SU}(2)$ and $X_{\mathbb{C}} := \mathsf{Hom}(\pi, \mathsf{SL}(2, \mathbb{C}))//\mathsf{SL}(2, \mathbb{C})$ preserving a symplectic (respectively complex-symplectic) structure. We show that Γ acts ergodically on X by relating Dehn twists τ_c about simple closed curves $c \subset \Sigma$ in Γ to generalized twist flows, which are Hamiltonian flows of trace functions f_c.

More generally, let S be a set of simple closed curves on Σ. Then the subgroup Γ_S generated by τ_c, for $c \in S$ acts ergodically on X whenever the functions f_c, for $c \in S$, generate the coordinate ring of $X_{\mathbb{C}}$. We apply these ideas when S consists of separating simple closed curves and Γ_S is the corresponding subgroup of the Johnson-Torelli group. (Received September 15, 2008)

1046-57-1203 **Li Chen*** (lchen@udc.edu), 4200 Connecticut Ave, N.W., Department of Computer Science and IT, University of the District of Columbia, Washington, DC 20008, and **Yongwu Rong**. *A Fast Algorithm for Homology Groups in 3D Cubical Space.*

This talk presents a linear time algorithm to compute homology groups of 2D or 3D objects in 3D cubical space. Without pre-calculating triangulation of real data, our algorithm will directly use the geometrical and topological properties of digital space to get local surface points, calculate the the genus, and homology groups. This algorithm is in linear time. At the last, we will show the real data examples for medical image analysis. (Received September 15, 2008)

1046-57-1240 **Hans U. Boden*** (boden@mcmaster.ca), Department of Mathematics and Statistics, McMaster University, 1280 Main St. W., Hamilton, Ontario L9H 4C3, Canada, and **Stefan Friedl**. *Metabelian SL(n,C) representations of knot groups.*

In this talk, which is a report on joint work with Stefan Friedl, I will explain why, for n prime (or more generally n a prime power), every irreducible metabelian SL(n,C) representation of a knot group factors through a finite group. It is a consequence that every such representation is conjugate to an SU(n) representation and that there are only finitely many (up to conjugation). I will present a simple formula for this number in terms of the Alexander polynomial of the knot. These results are the natural n ≥ 2 generalization of results of Nagasato on metabelian SL(2,C) representations of knot groups. (Received September 15, 2008)

1046-57-1282 **Manjarrez-Gutierez Fabiola*** (fmanjarrez@ucdavis.edu), Department of mathematics, One shields avenue, davis, CA 95616. *Circular thin position for knots.*

We define *circular thin position* and *circular width* for knots in S^3. We use this to show that many knots have more than one non-isotopic incompressible Seifert surface. We also analyze the behavior of the circular width under some knot operations. (Received September 15, 2008)

1046-57-1340 **Scott A Taylor***, 5832 Mayflower Hill Road, Colby College, Waterville, ME 04901. *The bridge number of knots and links which differ from a split link by a rational tangle replacement.*

All but the most trivial rational tangle replacements on a split link produce a knot or link which is neither the unknot nor a split link. It is known that (usually) the genus of the knot or link produced increases as the distance of the rational tangle replacement increases. It is interesting to investigate what happens to other geometrically defined knot invariants as the distance increases. An understanding of what happens to the bridge number of the knot or link is beginning to emerge. The talk will describe the conjectural picture and present a few partial results. (Received September 15, 2008)

1046-57-1373 **Heather M. Russell*** (hrussell@math.uiowa.edu), University of Iowa Department of Mathematics, 15 MacLean Hall, Iowa City, IA 52242-1419, and **Julianna S. Tymoczko** (tymoczko@math.uiowa.edu), University of Iowa Department of Mathematics, 15 MacLean Hall, Iowa City, IA 52242-1419. *Crossingless matchings and the Springer representation.*

Springer varieties are subvarieties of the flag variety whose cohomology carries a representation of the symmetric group. Using Khovanov's construction of a family of Springer varieties X_{2n}, we apply topological techniques to obtain an explicit combinatorial definition of the Springer action on $H_*(X_{2n})$ in terms of dotted, crossingless matchings. We use this formulation to identify the Springer representations in *every* homology degree, proving the Springer representation on $H_k(X_{2n})$ is the irreducible representation corresponding to the partition $(2n-k,k)$. (Received September 15, 2008)

1046-57-1385 **Kerry Luse*** (lusek@trinitydc.edu), 125 Michigan Ave. NE, Washington, DC 20017, and **Yongwu Rong**. *A transition polynomial for signed Feynman diagrams.* Preliminary report.

We apply Jeager's notion of a transition polynomial to signed Feynman diagrams, also called chord diagrams. This polynomial contains useful topological information, such as genus of the diagram. The genus of these diagrams is important in the question of RNA folding. The structure of an RNA molecule can be discussed on three levels. It is the secondary structure that can be captured using a version of Feynman diagrams. We also classify all genus one Feynman diagrams. (Received September 15, 2008)

1046-57-1470 **Benjamin J Cooper*** (bjcooper@math.ucsd.edu), 9525 Genesee Ave #220, San Diego, CA 92121. *Three Manifold Cobordisms and Homotopy Lie Algebras.*

Let L is a homotopy Lie algebra with invariant trace. It is shown that this is equivalent to the existence of a module structure over a cobordism category of 3-manifolds and that its Lie algebra homology corresponds to a enlargement of this category. Consequences of this include an action of 3-manifold cobordisms on the graph homology associated to an operad and $H^{*-1}(X, T_X \otimes A)$ of a complex manifold X with coherent sheaf A of $\mathcal{O}_X$ modules. (Received September 15, 2008)

1046-57-1507 **Marc Culler*** (culler@math.uic.edu), Dept. of Mathematics (MC/ 249), University of Illinois at Chicago, 851 S. Morgan St., Chicago, IL 60607-7045, and **Steve Boyer**, **Peter B Shalen** and **Xingru Zhang**. *Characteristic subsurfaces, character varieties and Dehn fillings.*

We will describe joint work with Steve Boyer, Peter Shalen and Xingru Zhang that gives bounds on the distance (i.e. geometric intersection number) between exceptional Dehn filling slopes (i.e. slopes for which the Dehn filling produces a non-hyperbolic manifold). The proofs combine methods based on the characteristic submanifold theory with an analysis of character varieties. This talk will focus on the aspects that relate to character varieties. For the most part, the character varieties that arise are those of a free product of two cyclic groups; these appear when a Dehn filling produces a connected sum of lens spaces. (Received September 15, 2008)

1046-57-1702 **Heather M Molle*** (hmolle@math.uiowa.edu), Department of Mathematics, The University of Iowa, Iowa City, IA 52242. *The growth of the quantum hyperbolic invariants of the figure eight knot.* Preliminary report.

The quantum hyperbolic invariants of Baseilhac and Benedetti are based on a quantization of the dilogarithm. They give rise to invariants of decorated three manifolds with a hyperbolic structure, at levels N an odd counting number. In this talk we explore the growth of these invariants where the underlying manifold is the complement of the figure eight knot with the complete hyperbolic structure. We find that for certain choices of decoration, the invariants grow exponentially in N, where the growth rate is proportional to the volume of the complete hyperbolic structure. (Received September 16, 2008)

1046-57-1710 **Jozef H. Przytycki*** (przytyck@gwu.edu), 10005 Broad Street, Bethesda, MD 20814. *Gram determinants of planar states and Lagrangian tangles.*

We describe the work with Qi Chen on a solution of Rodica Simion problem of computing the Gram determinants of the type B Temperley-Lieb algebras. We sketch the work with Qiaoqi Zhu on Gram determinants of planar surfaces and speculate on the form of Gram determinants of Lagrangian tangles and their categorification. (Received September 16, 2008)

1046-57-1764 **Katherine S. Byler Kelm*** (kbyler@csufresno.edu), 5245 N. Backer Ave. M/S PB 108, Fresno, CA 93740-8001. *Pictures of the second homotopy module of a two-complex.* Preliminary report.

We compute the second homotopy modules for several families of two-dimensional CW complexes using the theory of pictures. (Received September 16, 2008)

1046-57-1765 **Rachel Roberts***, Department of Mathematics, Washington University, St Louis, MO 63130, and **John Shareshian**. *Non-right-orderable 3-manifold groups.*

We investigate the orderability of fundamental groups of 3-manifolds. We restrict attention to groups of the form

$$G = \langle t, a, b | a^t = a^{\phi_*}, b^t = b^{\phi_*}, t^p [a, b]^q = 1 \rangle,$$

where ϕ_* is any automorphism of the rank two free group $F = F(a, b)$ such that

- $[a, b]^{\phi_*} = [a, b]$, and
- the automorphism $\phi_\sharp$ of the abelianization $F/[F, F] \cong \mathbb{Z} \oplus \mathbb{Z}$ induced by ϕ_* lies in $SL_2(\mathbb{Z})$, with $|\mathrm{Trace}(\phi_\sharp)| > 2$.

In other words, ϕ_* is induced by an orientation preserving pseudo-Anosov homeomorphism ϕ of a once punctured torus. We show that if either $\mathrm{Trace}(\phi_\sharp) < -2$ and $\frac{p}{q} \in [1, \infty]$ or $\mathrm{Trace}(\phi_\sharp) > 2$ and $(p, q) = (1, 0)$ then $G(\phi, p, q)$ is not right orderable.

There is some overlap between this work and the work of Dąbkowski, Przytycki and Togha. (Received September 16, 2008)

1046-57-1872 **Marion Moore*** (marion@math.ucdavis.edu), 635 Adams St, Apt 8, Davis, CA 95616, and **Matt Rathbun**, Davis. *High Distance knots in 3-manifolds.*

We construct knots of arbitrarily high distance in 3-manifolds which poses strongly irreducible Heegaard splittings. The knots sit as cores of stabilizations of these Heegaard splittings. (Received September 16, 2008)

1046-57-1950 **Jason E Miller*** (millerj@truman.edu), 100 E Normal St, Kirksville, MO 63501. *Relative Critical Sets: structure and application.*

Originally motivated by wanting to extend the concept of Blum's medial axis to greyscale images in the hope of creating a method for describing shapes in medical images, the d dimensional relative critical set of a smooth function of n variables generalizes the critical set to a locus of codimension $n - d$. One might expect this locus of points to have a highly "irregular" structure, but it can be shown that except for at a set of codimension $n - 2$, relative critical sets of dimension d are smooth manifolds. The proof of this relies on techniques from singularity theory and knowledge of the geometry of the stratification of the space of real symmetric matrices. The structure theorem will be stated, some comments on its proof made, and some open questions posed and discussed. (Received September 16, 2008)

1046-57-2050 **Alexander N. Shumakovitch*** (Shurik@gwu.edu), The George Washington University, Department of Mathematics, Monroe Hall, 2115 G St. NW, room 240, Washington, DC 20052. *Patterns in odd Khovanov homology.* Preliminary report.

In this talk we discuss an odd version of the Khovanov homology recently introduced by Peter Ozsváth, Jacob Rasmussen and Zoltán Szabó. We investigate experimental data obtained by computing this odd homology for all prime knots with up to 15 crossings and discuss its properties that appear to be drastically different from those of the ordinary (even) Khovanov homology. We present numerous applications of the odd Khovanov homology such as finding upper bounds for the Thurston-Bennequin number and detecting quasi-alternating and transversely non-simple knots. Finally, we consider interconnections between several generalizations of the odd Khovanov homology due to Krzysztof Putyra. (Received September 16, 2008)

1046-57-2121 **Ivan A. Dynnikov***, Dept. of Mechanics and Mathematics, Moscow State University, GSP-1, Moscow, 119991. *A geometrical approach to the braid conjugacy problem* Preliminary report.

I will speak about an approach to the Conjugator Search problem in braid groups based on analyzing the structure of the homeomorphism of a puncutred disc representing the given braid. The approach is conjectured to give an algorithm which is polynomial in both braid length and braid index. This work is in progress. (Received September 22, 2008)

58 ► Global analysis, analysis on manifolds

1046-58-827 **William E. Gryc*** (wgryc@gmail.com), Department of Mathematics, Dansby Hall, Morehouse College, 830 Westview Dr., Atlanta, GA 30314. *On the Holonomy of the Coulomb Connection over Manifolds with Boundary.*

Consider the quotient $\mathcal{A} \to \mathcal{A}/\mathcal{G}$ of Yang-Mills theory, where $\mathcal{A}$ is a space of connections of a principal bundle P and $\mathcal{G}$ are the gauge transformations. Narasimhan & Ramadas showed that the restricted holonomy group of the Coulomb connection is dense in the connected component of the identity of the gauge group when $P = S^3 \times SU(2) \to S^3$. Instead of a base manifold S^3, we consider a manifold of dimension $n \geq 2$ with a boundary and use *Dirichlet boundary conditions* on connections. A key step in the method of N. & R. consisted in showing that the linear space spanned by the curvature form at one specially chosen connection is dense in the holonomy Lie algebra. Our objective is to explore the effect of the presence of a boundary on this construction of the holonomy Lie algebra. We show that the linear space spanned by the curvature at any one connection is never dense in the holonomy Lie algebra. In contrast, the linear space spanned by the curvature form and its first commutators at the flat connection is dense. The former, negative, theorem is proven for any principal bundle, while the latter, positive, theorem is proven only for a product bundle over the closure of a bounded open subset of $\mathbb{R}^n$. (Received September 11, 2008)

1046-58-1804 **Melanie Anne Pivarski*** (pivarski@math.tamu.edu), Department of Mathematics, Mailstop 3368, Texas A&M University, College Station, TX 77843-3368. *Large Time Heat Kernel Asymptotics for Riemannian Polytopal Complexes and Finitely Generated Groups of Isometries.* Preliminary report.

We consider the behavior of the heat kernel, which is the fundamental solution to the heat equation, on a Riemannian polytopal complex, which is a polytopal complex with a Riemannian metric on each polytope. We are interested in the case where the Riemannian polytopal complex is a co-compact cover of a finitely generated group. Under some geometric assumptions on the complex, the large time on-diagonal behavior of the heat kernel on the complex is asymptotically equivalent up to constants to the return probability for the symmetric random walk on the group. (Received September 16, 2008)

60 ► Probability theory and stochastic processes

1046-60-61 **Qingshuo Song*** (qingshus@usc.edu), 3620 South Vermont Ave., KAP 108, Dept. of Math, USC, Los Angeles, CA 90089-253. *Portfolio optimization under subadditive transaction cost.*

This paper is concerned with portfolio optimization on finite time horizon. The transction cost function is required to be subadditive. The value function is characterized as a solution of system of quasi-variational inequalities (QVI). An alternative representation is discribed as free boudary problem. The value function of the portfolio optimization turns out to be a viscosity solution of system of QVIs. The uniqueness of the solution is also proved as one of the main results. (Received July 17, 2008)

1046-60-146 **Richard C. Bradley*** (bradleyr@indiana.edu), Department of Mathematics, Indiana University, Bloomington, IN 47405, and **Alexander R. Pruss** (Alexander_Pruss@baylor.edu), Department of Philosophy, Baylor University, One Bear Place #97273, Waco, TX 76798-7273. *A strictly stationary, N-tuplewise independent counterexample to the central limit theorem.*

For any given integer $N \geq 2$, there exists a strictly stationary sequence $(X_k, k \in \mathbf{Z})$ of random variables with the following properties: (i) the random variable X_0 is uniformly distributed on the interval $[-3^{1/2}, 3^{1/2}]$ (and hence $EX_0 = 0$ and $EX_0^2 = 1$); (ii) for every choice of N distinct integers $k(1), k(2), \ldots, k(N)$, the random variables $X_{k(1)}, X_{k(2)}, \ldots, X_{k(N)}$ are independent; (iii) the random variables $|X_k|, k \in \mathbf{Z}$ are independent; and (iv) for every infinite set $Q \subset \mathbf{N}$, there exist an infinite set $T \subset Q$ and a nondegenerate, non-normal probability measure μ on $\mathbf{R}$ such that $(X_1 + X_2 + \cdots + X_n)/n^{1/2}$ converges to μ in distribution as $n \to \infty$, $n \in T$. This example is a modification of a somewhat similar, nonstationary, N-tuplewise independent, identically distributed counterexample in Pruss [PTRF 111 (1998) 323-332]. It complements the strictly stationary, pairwise independent counterexamples in Janson [Stochastics 23 (1988) 439-448], and the strictly stationary, triplewise independent counterexamples developed in Bradley [PTRF 81 (1989) 1-10 and Rocky Mountain J. Math. 37 (2007) 25-44]. (Received August 06, 2008)

1046-60-365 **Rafael Mendoza*** (rafaelmendoza2008@u.northwestern.edu), IEMS, Northwestern University, 2145 Sheridan Road, Evanston, IL 60208, and **Vadim Linetsky** and **Peter Carr**. *Time Changed Markov Processes in Unified Credit-Equity Modeling.*

We develop a novel class of hybrid credit-equity models with state-dependent jumps, local-stochastic volatility and default intensity based on time changes of Markov processes with killing. We model the defaultable stock price process as a time changed Markov diffusion process with state-dependent local volatility and killing rate. When the time change is a Lévy subordinator, the stock price process exhibits jumps with state-dependent Lévy measure. When the time change is a time integral of an activity rate process, the stock price process has local-stochastic volatility and default intensity. When the time change process is a Lévy subordinator in turn time changed with a time integral of an activity rate process, the stock price process has state-dependent jumps, local-stochastic volatility and default intensity. We develop two analytical approaches to the pricing of credit and equity derivatives in this class of models. The two approaches are based on the Laplace transform inversion and the spectral expansion approach (if the payoff is square-integrable), respectively. (Received August 28, 2008)

1046-60-455 **Michael S. Kinnally*** (mkinnall@math.ucsd.edu), 9388 Redwood Dr., Apt. A, La Jolla, CA 92037, and **Ruth J. Williams**. *Stationary Solutions for One-Dimensional Stochastic Delay Differential Equations with Reflection.*

Deterministic dynamic models with delayed feedback and state constraints arise in the modeling of Internet rate control and of biochemical reactions involving transcription and translation. Much of the analysis of such deterministic models has focussed on stability analysis of equilibrium points. There is interest in understanding what effect noise has on the behavior of such systems. Here we consider a one dimensional stochastic delay differential equation with reflection as a simple prototype for a noisy analogue of a deterministic system with delayed feedback and state constraints. We obtain sufficient conditions for this system to have a unique stationary solution. We conclude with an example from Internet congestion control. (Received September 03, 2008)

1046-60-517 **Shiliang Cui*** (cuis@lafayette.edu), Lafayette College, Farinon Center, Box 7710, Easton, PA 18042, and **Evan Fisher** (fishere@lafayette.edu), Department of Mathematics, Lafayette College, Easton, PA 18042-1781. *The hitting time for a sequence pattern in a Markov chain.* Preliminary report.

The expected time for the first appearance of a pattern of letters generated by a Markov chain is obtained using a martingale argument. The approach is a variation of one used by Li (1980) in the i.i.d. case. (Received September 05, 2008)

1046-60-545 **Adina Oprisan*** (aoprisan@uta.edu), Department of Mathematics, The University of Texas at Arlington, Arlington, TX 76019, and **Andrzej Korzeniowski**, Department of Mathematics, The University of Texas at Arlington, Arlington, TX 76019. *Large deviations for Ergodic Processes in Split Spaces.*

We study a family of stochastic additive functionals of Markov processes with locally independent increments switched by jump Markov processes in an asymptotic split phase space. Based on an average approximation, we obtain a large deviation result for this stochastic evolutionary system using a weak convergence approach. Examples, including compound Poisson processes, illustrate cases in which the rate function is calculated in an explicit form. (Received September 07, 2008)

1046-60-558 **See Keong Lee*** (sklee@cs.usm.my), School of Mathematical Sciences, Universiti Sains Malaysia, 11700 Minden, Penang, Malaysia. *On Moment Conditions for Girsanov Theorem.*

The well known Girsanov Theorem is proved under a set of moment conditions on exponential processes. As an application, we show the nonexistence of an arbitrage in a market under this new conditions. (Received September 08, 2008)

1046-60-560 **Thomas B Fowler*** (tfowler@noblis.org), 3150 Fairview Park Drive, Falls Church, VA 22042. *Emergence of Heavy-Tailed Behavior and the Failure of the Central Limit Theorem Due to Hypercorrelation.*

Heavy-tailed distributions have become very important in fields as diverse as telecommunications and economics. They often occur in situations where one would expect that the Central Limit Theorem should apply. This research investigates why the Central Limit Theorem fails, and shows one mechanism by which heavy-tailed behavior can arise. This is by addition of what the research defines as "hypercorrelated" random variables. The research also shows that heavy-tailed behavior cannot arise due to addition of linearly related random variables. (Received September 08, 2008)

1046-60-584 **Mylan Redfern*** (mredfern@valdosta.edu), Department of Mathematics & Computer Science, Valdosta State Univesity, 1500 North Patterson Street, Valdosta, GA 31698-0040. *Complex Itô Formulas.*

This paper continues the development of complex white noise analysis on the space, $(\mathcal{D}^*_{\mathbb{C}})$, of complex Wiener distributions. For a certain class of functions $F : \mathbb{C}^m \to \mathbb{C}$ and complex Wiener integrals $\Phi = \Phi_1, \ldots, \Phi_m$, formulas for $\frac{d}{dt}F(\Phi)$ are developed. For $F : \mathbb{R}^m \to \mathbb{R}$, and real Wiener integrals $\phi_{\mathbb{R}}$, the Itô formula for $F(\phi_{\mathbb{R}})$ is obtained in the complex setting. (Received September 08, 2008)

1046-60-587 **Mariana Olvera-Cravioto*** (molvera@ieor.columbia.edu), 306 S. W. Mudd Building, 500 W. 120th Street, New York, NY 10027, and **Peter W. Glynn**. *Approximations for the waiting time distribution in an M/G/1 queue with heavy tails.*

We consider an M/G/1 queue with heavy-tailed processing times, in particular, having either a regularly varying or semiexponential distribution. It is well known that when the traffic intensity is close to one, the steady-state distribution of the waiting time can be approximated accurately by the heavy-traffic approximation. On the other hand, given the heavy-tailed nature of the processing times, the tail distribution can also be approximated by the so-called heavy-tailed asymptotic. These two approximations are very different in nature, with the former predicting an exponentially decaying tail, and the latter a subexponential one.

Our results provide new approximations that are uniform in the traffic intensity, and from which one can easily recover both the heavy-traffic and heavy-tailed approximations by looking at appropriate combinations of the traffic intensity and tail values. In the case of the M/G/1 queue with regularly varying processing times, it is shown that the tail distribution sharply transitions from the heavy-traffic domain to the heavy-tailed domain, while for the queue with semiexponential processing times we can identify a third, intermediate region.
(Received September 08, 2008)

1046-60-604 **Ira Gerhardt*** (i-gerhardt@northwestern.edu), 2145 Sheridan Rd, Room C210, Evanston, IL 60613, and **Barry L. Nelson** (nelsonb@iems.northwestern.edu), 2145 Sheridan Rd, Room C210, Evanston, IL 60613. *Transforming renewal processes for simulation of nonstationary point processes.*

Simulation models of real-life systems often assume stationary (homogeneous) Poisson arrivals. Therefore, when non-stationary arrival processes are required it is natural to assume Poisson arrivals with a time-varying arrival rate. For many systems, however, this provides an inaccurate representation of the arrival process which is either more or less variable than Poisson. In this paper we extend techniques that transform a stationary Poisson arrival process into a non-stationary Poisson arrival process (NSPP) by transforming a stationary renewal process into a nonstationary, non-Poisson (NSNP) arrival process. We show that the desired arrival rate is achieved, and that when the renewal base process is either more or less variable than Poisson, then the NSNP process is also more or less variable, respectively, than a NSPP. We also propose techniques for specifying the renewal base process when presented properties of, or data from, an arrival process and illustrate them by modeling real arrival data.
(Received September 08, 2008)

1046-60-745 **George P Yanev*** (yanevgp@utpa.edu), Department of Mathematics, The University of Texas - Pan American, 1201 W. University Drive, Edinburg, TX 78539. *Is the distribution exponential when the record median equals the record midrange, on average?*

Consider a sample of record values $X(1), X(2), \ldots, X(m)$. We study characterizations of exponential and related distributions in terms of the regression of one record value with two other record values as covariates, i.e., for $1 \leq k \leq n-1$ and $r \geq 1$

$$E[\psi(X(n))|X(n-k) = u, X(n+r) = v] \qquad (l_F < u < v < r_F),$$

where $\psi(x)$ satisfies certain regularity conditions and l_F and r_F are the extremity points of the underline absolutely continues distribution function F.

As a corollary of our main result we prove that F is exponential iff for $2 \leq k \leq n-1$

$$E[X(n)|X(n-k) = u, X(n+2) = v] = \frac{2u + kv}{k+2} \qquad (l_F < u < v < r_F).$$

Setting $k = 2$ above, we give an affirmative answer to the question in the title when the sample size is $m = 5$.

The obtained results compliment those in Yanev, G.P., Ahsanullah, M., and Beg, M.I. Characterizations of probability distributions via bivariate regression of record values. Metrika, 68(2008), 1:51-64. (Received September 10, 2008)

1046-60-778 **Hasanjan Sayit*** (hs7@wpi.edu), Mathematics Department, Worcester Polytechnic Institute, Worcester, MA 01609, and **Erhan Bayraktar** (erhan@umich.edu), Mathematics Department, Ann Arbor, MI 48502. *No Arbitrage Conditions For Simple Trading Strategies.*

We provide no arbitrage conditions for price processes in the class of simple trading strategies with shortsales restriction. Especially, we show that for price processes that admit local martingale measure but fails to have an equivalent martingale measure, the strong Markov property implies the no arbitrage property in the class of simple trading strategies with bounded support. Our result generalizes a similar result on three dimentional Bessel process. (Received September 11, 2008)

1046-60-833 **Aliakbar Montazer Haghighi*** (amhaghighi@pvamu.edu), Department of Mathematics, PO Box 519, MS 2225, Prairie View, TX 77446, **Stefanka S. Chukova**, School of Mathematics, Statistics and Compute, Wellington, New Zealand, and **Dimitar P. Mishev** (dimichev@pvamu.edu), Department of Mathematics, Prairie View A&M University, Prairie View, TX 77446. *A Single-server Poison Queueing System with Splitting and Delayed Batched Feedback (Case k = N = 1).*

A single-processor model with two input types: external Poisson and batched feedback are considered. The service station consists of an infinite buffer exponential single-server. After a task leaves the service station, it will do one of the following things: leaves the system with a probability, returns to the end of waiting buffer with a probability through a delay station; and proceeds to a splitter with a probability. The splitter splits the task into two subtasks, one returns to the waiting buffer through the delay buffer, and the other either leaves the system with a probability, or returns to the waiting buffer with a probability, through the delay buffer. The splitting is immediate. The delay station consists of an infinite buffer and a single delay processor. The movement process from the delay station to the service station is by an exponential finite batch. The delay processing starts only if there is at least a number of tasks in the delay buffer, called the threshold. After the processing at the delay station is completed, the processed batch joins the waiting buffer in the main service station. In this presentation we will focus on the case of a batch of size one. Here, the stationary algorithmic mean of queue size at each station is given. (Received September 11, 2008)

1046-60-907 **A Deniz Sezer*** (adsezer@ucalgary.ca), Department of Mathematics and Statistics, University of Calgary, Calgary, Alberta T2N1N4, Canada. *An information reduction model for credit risk based on level crossings of a diffusion.*

I will talk about a reduced information model for credit risk. In this model, the time when a company claims bankruptcy is the hitting time of the asset value process of the company, denoted by X_t, to a default threshold. The market can not observe X_t prior to bankruptcy, however it can observe $R(X_t)$, where $R(x) = i$, if $x_i < x < x_{i+1}$, where $x_1, ..., x_N$ are certain thresholds. I will explain how we derive zero coupon bond prices and default intensities when the X process is a diffusion. In the time remaining I will discuss open questions and future directions related to this model. (Based on joint work with Robert Jarrow and Philip Protter). (Received September 12, 2008)

1046-60-1107 **Chris Rogers** and **Luitgard Veraart*** (veraart@stoch.uni-karlsruhe.de), Institute for Stochastics, University of Karlsruhe, Kaiserstr. 89, 76133 Karlsruhe, Germany. *A Stochastic Volatility Alternative to SABR.*

We present two new stochastic–volatility models in which option prices for European plain vanilla options have closed–form expressions. The models are motivated by the well-known SABR model but use modified dynamics of the underlying asset. The asset process is modelled as a product of functions of two independent stochastic processes: a Cox–Ingersoll–Ross process and a geometric Brownian motion. An application of the model to options written on foreign currencies is studied. (Received September 14, 2008)

1046-60-1157 **John P. Nolan*** (jpnolan@american.edu), Math/Stat Dept., Gray Hall, 4400 Mass. Ave, NW, Washington, DC 20016-8050. *Lévy stable laws.*

This talk will be an overview of stable distributions. Stable laws are a class of distributions that have heavy tails and possible skewness. These laws generalize Gaussian laws in two (related) ways: sums of independent copies of stable are stable, and limits of normed sums of general independent terms converge to stable laws (Generalized Central Limit Theorem).

We will outline the univariate theory, describe computational methods for working with stable laws, and discuss statistical issues. Examples in a variety of applications will be given: network modelling, finance, and signal processing. A brief introduction to multivariate stable laws will also be given. (Received September 14, 2008)

1046-60-1171 **Sarah Bryant*** (snbryant@math.purdue.edu), Purdue University, 150 N. University St, Math Department, W. Lafayette, IN 47907. *Expected Time to See Flat Path of α Stable Process.*

Let Y_t be a standard one dimensional symmetric α stable process, $\alpha \in (0,2)$, and define $R(t,1) = \sup_{t-1\le s\le t} Y_s - \inf_{t-1\le s\le t} Y_s$ for $t \geq 1$. Given $\varepsilon > 0$, let $\tau(\varepsilon) = min\{t \geq 1 : R(t,1) \leq \varepsilon\}$. We prove exponential-type bounds for R and as a corollary $\lim_{\varepsilon\to 0} \varepsilon^\alpha \log E(\tau(\varepsilon)) = 2^\alpha \lambda_1$, where λ_1 is the first eigenvalue for the process Y_t in the interval $(-1,1)$. We prove some similar results, without exact constants, for dimension $d \geq 2$. (Received September 15, 2008)

1046-60-1193 **Jack Kim*** (jackkim@stanford.edu), 344 Olmsted Road Suite 237, Stanford, CA 94305, and **Kay Giesecke**. *Credit Portfolio Optimization.* Preliminary report.

We develop computationally tractable methods of optimizing the mark-to-market value of a portfolio of credit derivatives. We take a reduced-form, moment-based approach to the discrete horizon problem that can flexibly be ported to different default intensity models. (Received September 15, 2008)

1046-60-1210 **Sebastian Jaimungal*** (sebastian.jaimungal@utoronto.ca), University of Toronto, Department of Statistics, 100 St. George Street, Toronto, Ontario M5S3G3, Canada, and **Georg Sigloch** (Georg.Sigloch@utoronto.ca), University of Toronto, Department of Mathematics, 40 St. George Street, Toronto, Ontario M5S2E4, Canada. *Incorporating Risk Aversion and Model Uncertainty into Structural Models of Default.*

It is well known that purely structural models of default cannot explain short term credit spreads, while purely intensity based models of default lead to completely unpredictable default events. Neither of these features is realistic. Furthermore, investor preference may play an important role in introducing correlation of defaults as well as setting spreads themselves. Leung, Sircar and Zariphopoulou(2008) recently introduced a structural model, in which default of the reference entity is triggered by a credit worthiness index correlated to its stock price and utilized indifference pricing to value defaultable bonds. We take this base structural model and add a new regime which allows for unpredictable defaults, thus creating a hybrid model of default. Furthermore, in an unrelated paper, Uppal and Wang(2003) study portfolio optimization when model parameters are unknown. By combining the hybrid default model with the uncertain parameter portfolio optimization problem, we succeed in determining corporate bond spreads and CDS spreads using indifference valuation. Our framework therefore allows for risk aversion, parameter uncertainty and both structural and intensity default features. (Received September 15, 2008)

1046-60-1222 **Steve - Smale*** (smale@math.berkeley.edu) and **Nat Smale**. *Hodge Theory for Singular Spaces.*

It is useful to have the power of Hodge theory on spaces which are not manifolds and the measure is not uniform. A prime example of such a space is the space of images, important in the theory of pattern recognition. A Hodge decomposition result for square integrable forms on a metric space will be presented. (Received September 15, 2008)

1046-60-1254 **Ling Wu*** (lwu5@mail.usf.edu), Department of Mathematics & Statistics, University of South Florida, 4202 East Fowler Avenue, PHY 114, Tampa, FL 33620-5700, and **Gangaram S. Ladde** (gladde@cas.usf.edu), Department of Mathematics & Statistics, University of South Florida, 4202 East Fowler Avenue, PHY 114, Tampa, FL 33620-5700. *Nonlinear Stochastic Modeling and Statistic Analysis.* Preliminary report.

By introducing the concept of data partitioning, nonlinear stochastic models are inverstigated. These models are varidated with monthly stock price dataset. In addition, the results of these models are compared with GBM models. Furthermore, the developed results are further improved by developing nonlinear stochastics models with mixing jumps. These developments are re-examined and re-tests for two set of stock price datasets with different sizes. (Received September 15, 2008)

1046-60-1277 **Andrzej Korzeniowski*** (korzeniowski@uta.edu), Department of Mathematics, Box 19408, 411 S. Nedderman Drive, 478 Pickard Hall, Arlington, TX 76019. *On Random Network Dynamics.* Preliminary report.

We study finite networks in which each node follows its own internal random dynamics subjected to external random perturbations and a predifined node interaction structure. Stability and other steady-state properties are established and illustrated by examples. (Received September 15, 2008)

1046-60-1287 **Erhan Bayraktar**, 2846 East Hall, 530 Church Street, Ann Arbor, MI 48104, and **Hao Xing*** (haoxing@umich.edu), 3080 East Hall, 530 Church Street, Ann Arbor, MI 48104. *Regularity of the American put price in exponential Lévy models.*

In this talk, we will discuss some new results on the regularity of the American put price in exponential Lévy models with non-degenerate diffusion component. Under some conditions on the Lévy measure, we show that the price function is a classical solution of the free boundary problem. The regularity of the value function when the Lévy measure has finite activity was already known. Here, we extend these results to the Lévy measures that have infinite activity.

So far different notions of generalized solutions were used to describe the price funtion: solutions in viscosity sense by Pham and solutions in distribution sense by Lamberton and Mikou. This a joint work with Erhan Bayraktar. (Received September 15, 2008)

1046-60-1293 **Paul H Bezandry***, 2441 6th Street, NW, Washington, DC 20059. *Existence of almost periodic solutions to some functional integro-differential stochastic evolution equations.*

We investigate a class of abstract functional integro-differential stochastic evolution equations in a real separable Hilbert space. Under some suitable assumptions, we establish the existence and uniqueness of a quadratic mean almost periodic mild solution. (Received September 15, 2008)

1046-60-1317 **Brigitta K Vermesi*** (bvermesi@math.rochester.edu), University of Rochester, Department of Mathematics, Hylan Building, Rochester, NY 14627. *Intersection exponents for biased random walks on discrete cylinders.*

We show that intersection exponents for asymmetric random walks on d-dimensional half-infinite discrete cylinders exist and are real analytic. As part of the argument, we prove convergence to stationarity of a time-inhomogeneous chain on random paths. Furthermore, we show this convergence takes place at exponential rate, an estimate obtained via a coupling of weighted half-infinite paths. (Received September 15, 2008)

1046-60-1325 **Ryan S. Gantner*** (rgantner@sjfc.edu), 3690 East Avenue, Rochester, NY 14450. *Stochastic limiting averages of zero-one sequences.*

We consider a particular family of sequences of zeros and ones with several properties. The zeros occur in clusters which are separated by clusters of ones. The lengths of these clusters are random, with their expectations growing according to some specified function. We ask which growth functions will yield sequences with convergent limiting averages. (Received September 15, 2008)

1046-60-1330 **John K McSweeney*** (mcsweeney@math.ohio-state.edu), Ohio State University, Mathematics Department, 231 W 18th ave, Columbus, OH 43210. *Coalescence Time for a Nonuniform Allocation Process with Applications to Biology and Computer Science.*

We study a process where balls are repeatedly thrown into n boxes independently according to some probability distribution $\mathbf{p}$. We start with n balls, and at each step all balls landing in the same box are fused into a single ball; the process terminates when there is only one ball left (coalescence). Let $c := \sum_j p_j^2$, the collision probability of two fixed balls. We show that the expected coalescence time is asymptotically $2c^{-1}$, under two constraints on $\mathbf{p}$ that exclude a thin set of distributions $\mathbf{p}$. One of the constraints is $c \ll \ln^{-2} n$. This $\ln^{-2} n$ is shown to be a threshold value: for $c \gg \ln^{-2} n$, there exists $\mathbf{p}$ with $c(\mathbf{p}) = c$ such that the expected coalescence time far exceeds

c^{-1}. Connections to coalescent processes in population biology (Most Recent Common Ancestor problem) and theoretical computer science are discussed. (Received September 15, 2008)

1046-60-1367 **Stephanie Sapp*** (sapp.stephanie@gmail.com), 7731 North Shore Drive, Spicer, MN 56288, and **Amol Kapila**. *On Certain Sequences of Dependent Random Variables.*

We investigate various generalizations of sequences of dependent binomial variables in which the conditional probability of a success in each trial is dependent upon the rate of success in previous trials. We explore the possibility of generalizing previous results to larger classes of random variables and to allow for the case in which the unconditional expectation of each random variable varies. An example of the models explored is the following:

$$E[X_{j+1}|\mathcal{F}_j] = \mu_{j+1} - \frac{\theta_j}{j}\sum_{i=1}^{j}\mu_i + \frac{\theta_j}{j}S_j,$$

where $\{X_1, X_2, \ldots\}$ is a sequence of random variables, $E[X_j] = \mu_j$, θ_j is a dependence parameter, $S_j = \sum_{i=1}^{j} X_i$, and $\mathcal{F}_j$ is the σ-field generated by $\{X_1, X_2, \ldots, X_j\}$. (Received September 16, 2008)

1046-60-1427 **Sara Biagini** and **Mihai Sirbu*** (sirbu@math.utexas.edu), 1 University Station, C1200, Austin, TX 78712. *A note on admissible strategies for general stochastic processes and applications.* Preliminary report.

"Doubling strategies" can generate a positive net return with probability one, thus violating the foundations of Mathematical Finance and the No-Arbitrage Pricing Theory. Since Harrison and Kreps, a wide variety of constraints has been proposed in order to rule out doubling strategies. The class of strategies widely used in the applications, like portfolio selection, are the bounded-from-below strategies, which have nice mathematical properties (the Ansel-Stricker Lemma) and a clear financial interpretation. However, if one wants to account for unbounded stock prices, this set of strategies is not large enough, as it may reduce to the trivial strategy only. There have been so far some proposals (e.g. Delbaen and Schachermayer 1998, in the superreplication price problem, Biagini and Frittelli for utility maximization) to define a good set of strategies in such a way to account for general asset prices and still preserve the features of the Ansel-Stricker Lemma. Even if the sets of strategies introduced perform well in the specific applications, both present some drawbacks. This note is an attempt to remove some of the drawbacks by defining a new class of admissible strategies when working with general stochastic processes. (Received September 15, 2008)

1046-60-1469 **Lerna Pehlivan*** (pehlivan@usc.edu), University of Southern California, 3620 South Vermont Ave., KAP 108, Los Angeles, CA 90089-2532. *No Feedback Card Guessing For Top To Random Shuffles.* Preliminary report.

There are n cards that are labeled 1 through n, where n is even. The cards are put face down and in perfect order on a table. The cards are top to random shuffled m times and placed face down on the table. Starting from the top the cards are guessed without feedback (i.e. whether the guess was correct or false and what the guessed card was) one at a time. We find a guessing strategy that would maximize the expected number of correct guesses. (Received September 15, 2008)

1046-60-1475 **Libor Pospisil** (lp2185@columbia.edu), Department of Statistics, 1255 Amsterdam Ave, New York, NY 10027, **Jan Vecer** (vecer@stat.columbia.edu), Department of Statistics, 1255 Amsterdam Ave, New York, NY 10027, and **Olympia Hadjiliadis*** (ohadjiliadis@brooklyn.cuny.edu), Department of Mathematics, 1314N Ingersoll Hall, Brooklyn College, C.U.N.Y., New York, NY 11209. *Formulas for Stopped Diffusion Processes with Stopping Times based on Drawdowns and Drawups.*

This paper studies drawdown and drawup processes in a general diffusion model. The main result is a formula for the joint distribution of the running minimum and the running maximum of the process stopped at the time of the first drop of size a. As a consequence, we obtain the probabilities that a drawdown of size a precedes a drawup of size b and vice versa. The results are applied to several examples of diffusion processes, such as drifted Brownian motion, Ornstein-Uhlenbeck process, and Cox-Ingersoll-Ross process. (Received September 15, 2008)

1046-60-1501 **Mark Burgin** (mburgin@math.ucla.edu) and **Alan Krinik*** (ackrinik@csupomona.edu), Alan Krinik, Department of Mathematics and Statistics, California State Polytechnic Univ., Pomona, Pomona, CA 91768. *Generalized Spaces of Random Variables.*

Let us assume that (S, F, P) is a probability space, A is an element of F and T is a cumulative partition of the real line and X is a real random variable. We define the expected hyper-value HMX over the event A as the hyper-integral of X over A [Burgin, M. Hyper-functionals and Generalized Distributions, in "Stochastic Processes and Functional Analysis", Dekker, 2004].

Theorem 1. The expected hyper-value HMX exists for any random variable X. At the same time, the expected value MX does not exist for all random variables X. In addition, the expected hyper-value allows one to discern random variables that have "different" types of infinite expected values. The following theorem gives one of the main properties of expected hyper-values.

Theorem 2. The expected hyper-value HMX coincides with the expected value MX if and only if HMX does depend on the partition T.

We study other properties of expected hyper-values. Many of these properties are similar to properties of expected values.

Theorem 3. The expected hyper-value HMX is a linear hyper- functional on the space of random variables and an additive hyper-functional on the space of probabilities. (Received September 15, 2008)

1046-60-1591 **Rhonda D. Phillips*** (rdphllps@vt.edu), 2050 Torgersen Hall (0106), Department of Computer Science, Blacksburg, VA 24061, and **Layne T. Watson** and **Randolph H. Wynne**. *A Hypothesis Test for Evaluating the Spectral Purity of Fuzzy Clusters.*

Semi-supervised classification algorithms use both labeled and unlabeled samples to construct a classification model with the objective of developing a better model without acquiring more labels, which is an expensive and difficult process. In large datasets, the "cluster assumption"—samples in a cluster are likely to share a label—is a reasonable way to incorporate millions or billions of unlabeled samples in the model without being computationally prohibitive. However, there are many cases where a significant number of samples within a cluster would not share a label, particularly when one cluster is composed of multiple true clusters. This work develops a hypothesis test for determining with a high probability that a particular fuzzy cluster is composed of primarily one class. This is particularly challenging because fuzzy cluster membership weights must be taken into account in addition to a priori labeled class memberships, and analytically determining a distribution for fuzzy cluster weights is problematic. The hypothesis test in this work assumes that the central limit theorem can be applied to sums of cluster weights, and included in this work is a rigorous argument for the satisfaction of the Lindeberg condition and the application of the central limit theorem. (Received September 16, 2008)

1046-60-1685 **Mauro Maggioni*** (mauro.maggioni@duke.edu), Duke University, 117 Physics Building, Box 90310, Durham, NC 27708. *"Harmonic and Multiscale Analysis on low-dimensional data sets in high-dimensions".*

"We discuss recent advances in harmonic analysis ideas and algorithms for analyzing data sets in high-dimensional spaces which are assumed to have lower-dimensional geometric structure. They enable the analysis of both the geometry of the data and of functions on the data, and they can be broadly subdivided into local, global and multiscale techniques, roughly corresponding to PDE techniques, Fourier and wavelet analysis ideas in low-dimensional Euclidean signal processing. We discuss applications to machine learning tasks, image processing, and discuss current research directions." (Received September 16, 2008)

1046-60-1721 **Julius N Esunge*** (esunge@math.lsu.edu), Department of Mathematics, 329 Lockett Hall, Baton Rouge, LA 70803, and **Hui-Hsiung Kuo** (kuo@math.lsu.edu), Department of Mathematics, 304 Lockett Hall, Baton Rouge, LA 70803. *On Anticipating Linear Stochastic Differential Equations.*

In this paper, we capture examples highlighting the solution of stochastic differential equations of anticipating type. Within the framework of white noise theory, such equations may be solved using the S-transform. This approach provides a useful remedy to the fact that the Itô theory of stochastic integration is inapplicable to such equations. (Received September 16, 2008)

1046-60-1743 **Birgit Rudloff*** (brudloff@princeton.edu), **Joern Sass** and **Ralf Wunderlich**. *Utility Maximization under Risk Constraints.*

It is well known that the optimal investment strategy in the classical utility maximization problem can be very risky. As a consequence, in recent research a risk constraint was added to the classical utility maximization problem to control the risky part. We study the utility maximization problem when a convex risk measure is used in the risk constraint. As a special case a lognormal model with partial information on the drift and an entropic risk constraint will be considered. The optimal terminal wealth and the optimal trading strategies are calculated. Numerical examples illustrate the analytic results. (Received September 16, 2008)

1046-60-1790 **Bogdan Doytchinov*** (doytchinovb@etown.edu), Department of Mathematical Sciences, One Alpha Drive, Elizabethtown College, Elizabethtown, PA 17022. *Time discretization of Markov chains: kick it up a notch.* Preliminary report.

We study a natural method for constructing, for a given continuous-time Markov chain, an approximating discrete-time Markov chain, with second and higher order of approximation. Stationary and limiting distributions will also be addressed. (Received September 16, 2008)

1046-60-1835 **Badal Joshi*** (badal@math.ohio-state.edu), 231 W 18th Avenue, Columbus, OH 43210, and **Janet Best**. *A Markov state model for wake-sleep transitions.*

We have shown that a Generalized Pareto distribution provides a good fit to the wake bout times in rat infants of several different ages. This allows us to make predictions about the bout distribution at ages for which experimental data is not available. In order to identify the neuronal mechanisms that generate the wake bout distribution, we construct a Markov state model. The sub-states may represent the activity of different wake-active neuronal populations, and the transition rates provide clues to their interactions. We derive and state constraints on the architecture and the transition rates in the Markov model in order to obtain a Generalized Pareto distribution. (Received September 17, 2008)

1046-60-1860 **Dervis Bayazit*** (dbayazit@math.fsu.edu), FSU Mathematics, 208 Love Building, 1017 Academic Way, Tallahassee, FL 32306-4510, and **Craig A. Nolder** (nolder@math.fsu.edu), FSU Mathematics, 208 Love Building, 1017 Academic Way, Tallahassee, FL 32306-4510. *An Exact Malliavin Weight for Variance Gamma and Normal Inverse Gaussian Processes: Sensitivity Analysis of European Style Options.* Preliminary report.

The main objective of this work is to find a Malliavin weight in order to calculate the delta of an European style option where the underlying asset is a Variance Gamma process or a Normal Inverse Gaussian process. We obtained a Malliavin integration by parts formula for a general multidimensional random variable which has an absolutely continuous law with a differentiable density for at least one of the dimensions. We give an explicit expression for the weight which is used in Monte Carlo simulations. We measure 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 that the Malliavin approach becomes extremely efficient for a discontinuous payoff.

Key words: Malliavin calculus, Monte-Carlo simulations, Varince Gamma process, Normal Inverse Gaussian process, sensitivity analysis, Fast Fourier Transform methods. (Received September 16, 2008)

1046-60-1912 **Maria Emelianenko*** (memelian@gmu.edu), Dept. of Math. Sciences, MS: 3F2, George Mason University, 4400 University Drive, Fairfax, VA 22031, and **David Kinderlehrer** and **Dmitry Golovaty**. *Nonlinear dynamical phenomena in mesoscale modeling of polycrystals.*

Polycrystalline materials are important in many technological applications, yet there are still many challenges they present for mathematical modeling and analysis. One such challenge lies in understanding how statistical distributions develop in the process of coarsening of materials microstructure and how these distributions in turn relate to materials properties. In this talk, we will discuss and compare several recent continuum level models resulting in nonlinear evolution equations. Special focus will be placed on newly discovered features of interface dynamics that connect this problem to the theory of nonhomogeneous Poisson processes in industrial applications and Boltzmann equations in statistical physics. Numerical and analytical characteristics of the solutions will be discussed and compared against the results produced by experiments and large-scale simulations. (Received September 16, 2008)

1046-60-1938 **Robert D Wooster*** (wooster@math.uconn.edu), 15 Baxter Road, Storrs Mansfield, CT 06268. *Evolution systems of measures for non-autonomous stochastic differential equations with Lévy noise.*

The notion of an evolution system of measures for a non-autonomous stochastic differential equation is the natural analogue of a stationary measure for an autonomous stochastic differential equation. We will investigate conditions under which there exists a unique evolution system of measures for the Ornstein-Uhlenbeck type SDE

$$dX(t) = A(t)X(t)dt + dZ(t),$$

where $Z(t)$ is a d-dimensional Lévy process and $A : \mathbb{R} \times \mathbb{R}^d \to \mathbb{R}^d$.

This work was done with support from Michael Röckner of the University of Bielefeld. (Received September 16, 2008)

1046-60-2032 **Roger Lee*** (RL@math.uchicago.edu) and **Peter Carr**. *Volatility Derivatives on Time-Changed Levy Processes.*

Under stochastically time-changed Levy dynamics, we price volatility derivatives in terms of Europeans. Extending previous work of Carr-Lee, we time-change a general Levy process – including jumps – and we find exact pricing solutions under dynamics which generate asymmetric volatility skews. (Joint with Peter Carr) (Received September 16, 2008)

1046-60-2042 **Tim S.T. Leung*** (timleung@jhu.edu), 302 Whitehead Hall, 3400 N Charles St, Johns Hopkins University, Baltimore, MD 21218. *Exponential Hedging with Optimal Stopping and Static-dynamic Hedging.*

We study the problem of hedging early exercisable (American) claims with respect to exponential utility within a general incomplete market model. This leads us to construct a duality formula involving relative entropy minimization and optimal stopping. We further consider claims with multiple exercises, and static-dynamic hedges of American claims with other European and American options. (Received September 16, 2008)

1046-60-2126 **Stuart Geman*** (Stuart_Geman@brown.edu), Brown University, Division of Applied Mathematics, 182 George Street, Providence, RI 02912. *Google and the Vapnik-Chervonenkis Dimension*

Google engineers routinely train query classifiers, for ranking advertisements or search results, on more words than any human being sees or hears in a lifetime. A human being who sees a meaningfully new image every second for one-hundred years will not see as many images as Google has in its libraries, all of which are available for training object detectors and image classifiers. Yet by human standards the state-of-the-art, in computer understanding of language and computer-generated image analysis, is primitive. What explains the gap? Why can't learning theory tell us how to make machines that learn as efficiently as humans? Upper bounds on the number of training samples needed to learn a classifier as rich and competent as the human visual system can be derived using the Vapnik-Chervonenkis dimension, or the metric entropy, but these suggest that not only does Google need more examples, but all of evolution might fall short. I will make some proposals for efficient learning and offer some mathematics to support them. (Received September 26, 2008)

1046-60-2131 **Gunnar Martinsson*** (martinss@colorado.edu), Department of Applied Mathematics, University of Colorado at Boulder, 526 UCB, Boulder, CO 80309-0526. *Fast Matrix Computations via Randomized Sampling*

Matrix computations lie at the heart of many algorithms for extracting information from the massively large data sets that arise in applications such as the study of large networks (e.g. the world wide web) and analysis of genomic data. A core outstanding challenge is the construction of algorithms for performing these matrix computations rapidly and accurately.

In developing such algorithms, valuable lessons can be learned from existing fast techniques for matrix computations such as the Fast Multipole Method, multigrid, etc. However, almost all such techniques that we currently know rely on special structure in the problem that is known in advance, for instance that the matrix under consideration represents the discretization of a PDE with known spectral properties. In the new applications that we face, such a priori information is typically not available.

In this talk, we will describe some situations in which the use of randomized sampling techniques has enabled the construction of fast algorithms even when little a priori information about the structure of the data is available. We will discuss connections between this work and other randomized algorithms; in particular the connection to recent work in functional analysis and probability theory (by Johnson and Lindenstrauss, Bourgain, and others) utilizing random projections to embed objects into low-dimensional Euclidean spaces, while preserving important geometrical properties of the objects. (Received October 01, 2008)

62 ► Statistics

1046-62-125 **Mavis Pararai*** (pararaim@iup.edu), Mathematics Department, Indiana University of Pennsyvania, Indiana, PA 15705. *Measurement Errors in the Generalized Poisson-Poisson Regression Model.* Preliminary report.

Count data regression models have been widely used in statistics to model response variables that are assumed to have been correctly reported. This assumption might be violated as some counts might be misreported. The generalized Poisson-Poisson mixture regression (GPPMR) model is developed to model counts that are accurately reported, underreported and overreported. The GPPMR model is applied to two data sets: (1)

National Pregnancy and Health Survey (NPHS) Data and (2) School Crime Supplement Data. The GPPMR model is compared to the Negative Binomial-Poisson mixture regression (NBPMR) model. The two models seem to perform equally the same with the Negative Binomial-Poisson mixture regression model performing better than the GPPMR model. Finally, a simulation study is conducted to investigate the properties of the maximum likelihood estimates of the parameters of the GPPMR model. (Received July 29, 2008)

1046-62-483 **Broderick Oluyede*** (boluyede@georgiasouthern.edu), Department of Mathematical Sciences, Georgia Southern University, Statesboro, GA 30460, and **Norou Diawara**, Department of Mathematics and Statistics, Old Dominion University, Norfolk, VA 23529. *On Mean Advantage Over Inferiors Ordering and Weighted Distributions.*

In this note, some fundamental results on the mean advantage over inferiors functions and weighted distribution functions are established. Ordering of reliability and/or distribution functions via mean advantage over inferiors functions and related functions for parent and weighted reliability functions are presented. Some applications and examples are given. (Received September 04, 2008)

1046-62-580 **K K Saha*** (sahakrk@ccsu.edu), Department of Mathematical Sciences, 1615 Stanley Street, New Britain, CT 06053. *Tests for the Equality of the Means in the Analysis of Clustered Count Data.*

Clustered count data occurring in a variety of applications in biology, toxicology, ecology, clinical medicine, epidemiology and other similar fields often exhibit extra-dispersion (overdispersion or underdispersion) than predicted by a simple Poisson model. This arises when the data are grouped or when the assumption of independence is violated. In this communication, we discuss several procedures for testing the equality of the means of clustered count data when extra-dispersions among the treatment groups are equal or unequal. The simulation study indicates that the statistic based on the adjusted count data, which does not require any specific model for the extra-dispersion, holds the best performance characteristics over the other statistics. Analysis of the real life data arising from biostatistical practices is presented. (Received September 08, 2008)

1046-62-629 **Hong Li*** (honli@bgsu.edu), 707 Sixth St., Apt.6, Bowling Green, OH 43402. *All-pairwise Comparisons for populations with Unequal Error Variances.* Preliminary report.

Tukey (1953) method provided simultaneous inference for all-pairwise comparisons under balanced design and usual normality and equality of variances assumption. Under unbalanced design, Tukey-Kramer procedure gave a set of conservative simultaneous confidence intervals for all-pairwise differences, and has been widely used. These methods assume the variances are equal across all treatment groups. In practice, however, homogeneity of variances is seldom satisfied. In this article, an approximate approach for all-pairwise comparisons is proposed when the equality of variances can not be assumed. Type I error rate for both Tukey-Kramer procedure and the proposed method is calculated through a simulation study. The results showed that the error rate of Tukey-Kramer method is excessive, and it is more than four times the nominal level when the variances are different among all treatment groups, and the variance and the sample size are inversely paired. While all the error rates of the proposed method are within the nominal level. (Received September 16, 2008)

1046-62-699 **Veera Holdai*** (vxholdai@salisbury.edu), 1101 Camden Ave., Salisbury, MD 21801, and **Alexander Korostelev** (apk@math.wayne.edu). *Image Reconstruction in Multi-Channel Model under Gaussian Noise.*

The image reconstruction from noisy data is studied. A nonparametric boundary function is estimated from observations in a growing number, N, of independent channels in the Gaussian white noise. In each channel, the image and the background intensities are unknown. They define a set of unidentifiable nuisance parameters that slow down the typical minimax rate of convergence. The asymptotically minimax rate is found as $N \to \infty$, and an asymptotically optimal estimator of the boundary function is suggested. (Received September 10, 2008)

1046-62-797 **Abbas M. Alhakim*** (aalhakim@clarkson.edu), 8 Clarkson Avenue, Science Center 5815, Potsdam, NY 13699. *A Spectral Look at the Serial test of Randomness.* Preliminary report.

The overlapping serial test of randomness collects statistics from a sequence of values from a finite set by observing the overlapping blocks of two consecutive pre-specified sizes. We give a version of this test with a chi-square statistic having much lower degrees of freedom. This is based on the spectral properties of the limiting covariance matrix of the counts of overlapping blocks. In particular, the information gained by incrementing the block size by one unit is seen to be solely conveyed by the eigenvectors of the lowest nonzero eigenvalue, which are thus used to construct the proposed chi square statistic. Better still, these eigenvectors are further split according to their symmetries into two sets that reveal two different attributes of the underlying sequence being tested, for uniformly distributed sequences. We also demonstrate this by simulation. (Received September 11, 2008)

1046-62-977 **Jiaping Wang*** (jwang@math.binghamton.edu), Mathematical Science Department, PO BOX 6000, Binghamton, NY 13902-6000, **Qiqing Yu**, Mathematical Science Department, PO BOX 6000, Binghamton, NY 13902-6000, and **George George Y. C. Wong**, Strang Cancer Prevention Center, 428 E 72nd Street, Ithaca, NY 10021. *The Generalized MLE With Interval-Censored And Masked Competing Risks Data.*

We consider the estimation problem of the joint cumulative distribution function (cdf) of the failure time T and the failure cause C of a J-component series system. The study is motivated by a cancer research data with interval-censored (IC) T and masked C. This type of data is called the interval censored and masked competing risks (ICMCR) data. We propose to estimate the cdf by the generalized maximum likelihood estimator (GMLE). In general, there is no explicit solution for the GMLE based on the ICMCR data. We discuss the algorithm for the GMLE. We show that with the continuous right-censored and masked competing risks data the standard GMLE is inconsistent. However, our simulation results suggest that with ICMCR data the GMLE is consistent. Moreover, we study the empirical convergent rates of the GMLE through simulation. (Received September 13, 2008)

1046-62-1061 **Joseph B. Liddle*** (jbliddle@uas.alaska.edu), 609 Sawmill Creek Road, Sitka, AK 99835, and **Aron Crowell** and **Mark Matson**. *Spatial Analysis of Archaeological Sites Associated with Subsistence Resources in Coastal South Central Alaska.* Preliminary report.

GIS maps reveal that clustering of archaeological sites in the Gulf of Alaska region are driven by spatial patterns of marine resources. We used spatial models fitted with the Metropolis-Hastings algorithm to analyze site distribution. We found that salmon streams, herring, halibut, cod, sea bird colonies and seal rookeries are all associated with archaeological sites. We infer different site selection strategies within the several sub-regions depending on which resources are most available. (Received September 14, 2008)

1046-62-1198 **Amol Kapila*** (amol_kapila@brown.edu), 2420 Del Lago Drive, Fort Lauderdale, FL 33316, and **Stephanie Sapp** (sapp.stephanie@gmail.com). *On the Two-Sided Power Distribution.*

The Two-Sided Power distribution is a relatively new probability distribution introduced by van Dorp and Kotz in 2002. We derive approximate most-powerful critical regions for hypothesis testing, where the underlying distribution is assumed to be a TSP distribution. This serves as a useful illustration of the Neyman-Pearson Lemma. (Received September 15, 2008)

1046-62-1245 **Boubakari Ibrahimou*** (bibrahim@health.usf.edu), 13201 Bruce B. Downs Blvd., MDC 56, Tampa, FL 33612. *Statistical Analysis of Aggregated, Spatiotemporally Clustered Proportions.* Preliminary report.

In this paper, we are presenting an aggregated and spatiotemporally clustered data set. Our main interest is in discussing different methods of analysis including: 1- Naïve and traditional approach 2- Group comparison via t-test 3- Longitudinal analysis Finally an application to farm workers injury prevention data set will be presented. (Received September 15, 2008)

1046-62-1519 **JINFENG WEI*** (jwei@maryville.edu), 650 Maryville University Dr., St. Louis, MO 63141, and **T.C. SUN**. *Rainflow Cycles Counting Method to Assess Time Series Models for Terrain Profiles.*

For non-linear, non-Gaussian, and non-stationary Perryman3 terrain profile, we propose three non-linear models ARMA-GARCH model, TAR model, and EMD model.

We use Rychlik's rainflow cycle counting method to count the oscillation amplitudes and cycles for the three simulation profiles and the original profile respectively and compare them. The roughness of the terrain topography will greatly affect the parts's life and the dynamics system of a vehicle. The oscillation will cause parts deformation and fatigue damage. The life of parts to failure is determined by oscillation amplitudes and cycles.

We found that the simulation of the ARMA-GARCH model has fewer cycles with smaller amplitudes than that of the original profile. The rainflow cycles of TAR model simulation has the same phenomena as that of the ARMA-GARCH Model. But TAR model simulation has more cycles with bigger amplitudes than that of the original profile. So the TAR model can describe the bump part very well. The histogram of the rainflow cycles of the EMD model simulation has a similar pattern with that of the original profile. So the rainflow cycles of the

EMD model matches that of the original profile best. So the EMD model is the best choice for the Perryman3 profile data. (Received September 15, 2008)

1046-62-1535 **Mingfu Zhu*** (mzhu@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634, **Shuhong Gao**, Department of Mathematical Sciences, Clemson University, Clemson, SC 29634, and **Guangran Jiang**, Department of Computer Science, Zhejiang University, Hangzhou, Zhejiang , Peoples Rep of China. *Proving the 100 Swiss Francs conjecture.*

Sturmfels offered 100 Swiss Francs in 2005 to a conjecture, which deals with a special case of the maximum likelihood estimation for a latent class model. A positive solution for this conjecture will be presented in this talk. (Received September 15, 2008)

1046-62-1542 **Greg Brockman*** (gbrockm@fas.harvard.edu), 1145 Harvard Yard Mail Center, Cambridge, MA 02138, and **Sunil Abraham**. *Omnibus Sequences.*

Consider locating words of length k as subsequences of a random string of length n. How large should n be in order to ensure with high probability that all k words are present, where a is the alphabet size? In this paper we consider necessary and sufficient conditions for such to occur, and we provide probabilistic and statistical analyses of their frequency. Efficient listings of words have been previously studied using universal cycles; however, the method we present requires a significantly shorter string to encode the same number of words. Several potential applications are presented. For example, this paper demonstrates how Tolstoy's War and Peace contains this abstract, or any other abstract of this length. (Received September 15, 2008)

1046-62-1572 **Nabin K. Shrestha*** (nmanandh@mail.usf.edu), 4102 Skipper Road, Apt. 209, Tampa, FL 33613, and **K. M. Ramachandran**, 4202 E. Fowler Avenue, PHY 114, University of South Florida, Department of Mathematics and Statistics, Tampa, FL 33620. *Behrens Fisher's Distribution for selecting Genes and its Application in Cancer Classification.*

Microarray expression experiments allow the recording of expression levels of thousands of genes simultaneously. Such data have been useful for classifying different types of cancers. Majority of literature on this topic assumes equality of variance between control and treatment samples. Because the variance of the expression levels in different classes are generally different due to the nature and response of the mRNA at the different conditions, the classification methods should take account of this information. In this paper, we have proposed a new method of selecting informative genes based on the Bayesian Version of Behrens-Fisher distribution. We have found that the proposed method selects the genes that are useful for classification and gives the better classification result by improving classification accuracy. The efficiency of this method has been demonstrated by applying them in three real microarray data. We have compared our result with some of the other popular methods that are found in the literature. (Received September 16, 2008)

1046-62-1783 **Akram M. Almohalwas*** (almoh1am@cmich.edu), 616 S. Pine St., Mt. Pleasant, MI 48858. *Nonparametric statistics applied on simulated data and some Gene Expression data.* Preliminary report.

Most of the gene expression data have more variables than samples. This requires some data mining techniques in order 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 without restricting data to be normally distributed. Simulation study suggested that using nonparametric statistic one can classify genetic diseases with very high accuracy. Same results gained when nonparametric statistics applied to classify genetic diseases real data sets.
(Received September 16, 2008)

1046-62-1901 **William W Hager** (hager@math.ufl.edu), PO Box 118105, Department of Mathematics, University of Florida, Gainesville, FL FL 32611, **Jiangtao Luo*** (jiangtl@math.ufl.edu), Po Box 118105, Department of Mathematics, University of Florida, Gainesville, FL FL 32611, and **Rongling Wu** (rwu@ufl.edu), PO Box 110339, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL FL 32611. *A Computational Model for Functional Mapping of Genes that Regulate HIV Drug Therapy and Virus Load.*

Genes have been recognized to control
the development of HIV, but have been difficult to detect
because the growth dynamic of it is sensitive to environmental changes.

We present a statistical model for mapping
and characterizing specific genes or quantitative trait loci (QTL)

that affect treatment of HIV. This model integrates
a system of differential equations into the framework for
functional mapping, allowing for the hypothesis tests of the
interplay between genetic actions and HIV drug therapy. We study the properties of the statistical model and a
simulation approach based on treatment and virus load has been designed to test statistical properties of the model.

The model will have great implications
for probing the molecular genetic mechanism of HIV drug therapy through the detection of the corresponding QTL throughout the genome. (Received September 16, 2008)

65 ► Numerical analysis

1046-65-14 **Douglas N. Arnold***, School of Mathematics, 512 Vincent Hall, 206 Church St. SE, University of Minnesota, Minneapolis, MN 55455. *Stability, Consistency, and Convergence: Modern Variations on a Classical Theme.*

The accuracy of a numerical discretization of a mathematical problem depends on the consistency and stability of the discretization method used. This theme, that consistency and stability imply convergence, recurs throughout numerical analysis, and is especially important in the numerical solution of partial differential equations. But the concept of numerical stability can be subtle and elusive. Even simple examples can yield unexpected results, and the development of stable numerical methods remains elusive for important classes of problems. We will survey these ideas through a variety of examples, and describe some modern tools from geometry and topology which are taking their place along side the more classical analytic tools for designing and understanding stable algorithms. (Received September 14, 2008)

1046-65-32 **Liying Sun*** (sly@gdei.edu.cn). *Constraint preconditioning for nonsymmetric indefinite linear systems.*

In this paper, we consider preconditioning the real, nonsymmetrical, and indefinite systems of linear equations. We extend the Schilders' factorization of the preconditioner to a nonsymmetrical matrix by using the different factorization from the recent results. The eigensolu- tion distribution of the preconditioned matrix is determined. The choices of the parameter matrices in the extended Schilder's factorization are discussed. An upper bound of the degree of the minimal polynomial for the preconditioned matrix and the dimension of the corresponding Krylov subspace are determined, as well as the convergence behavior of a Krylov subspace method such as GMRES. (Received June 17, 2008)

1046-65-57 **Natasha A Cayco Gajic*** (naelxcg@caltech.edu), Applied and Computational Mathematics, Caltech, 1200 E. California Blvd. MC 217-50, Pasadena, CA 91125, **Nathan Kallus** (kallus@berkeley.edu), Dept. Mathematics, UC Berkeley, 970 Evans Hall #3840, Berkeley, CA 94720-3840, and **Jessica L Stigile** (jls2@cec.wustl.edu), Department of Computer Science, One Brookings Drive, St. Louis, MO 63130. *A numerical method for integration of rational functions.* Preliminary report.

Landen transformations are maps on an integrand that preserve the value of the integral. These originally appeared in the context of elliptic integrals. We present an implementation and numerical improvement of an integration technique based on Landen transformations of rational integrands developed by Boros, Manna, and Moll. The method presented deals with the problem of coefficient growth while preserving the fast order of convergence of the original procedure. We discuss the merits of the method as compared to standard integration techniques. (Received July 21, 2008)

1046-65-66 **Sarah Minerva Venuti*** (swelling@gmu.edu), 4400 University Drive, Mathematical Sciences, George Mason University, Fairfax, VA 22030, and **Kevin Kelbaugh** and **Padmanabhan Seshayer** (pseshaiy@gmu.edu). *Mathematical modeling, analysis and computation of a fluid-structure interaction problem with applications.* Preliminary report.

In this work, we consider the mathematical modeling and analysis of a fluid-structure interaction problem. The associated partial differential equations for the fluid which is coupled through the boundary with an elastic structure are studied using the finite element methods. Both linear as well as nonlinear (geometric and material) models will be considered in this study. Stability and convergence of the numerical methods employed will

be presented. The numerical solutions will be compared against exact solutions that will be obtained using analytical tools such as Laplace Transforms. The mathematical tools presented in this multidisciplinary project can be extended to understand and get a better insight to problems in the areas of medicine and aerospace. (Received July 18, 2008)

1046-65-73 **Leon Kaganovskiy*** (lkaganovskiy@ncf.edu), 3525 Cheshire Sq, apt B, Sarasota, FL 34237, and **Robert Krasny** (krasny@umich.edu) and **Feng Hualong** (hualongf@umich.edu). *Adaptive Quad-tree Surface Representation for 3-D Vortex Rings Motion and Collision.*

A panel method is presented for computing vortex sheet motion in 3D flow. The sheet is represented as a set of quadrilateral panels with a quad-tree structure. The panels have active particles that carry circulation and passive particles used for adaptive panel subdivision. The quadrature scheme does not require explicit derivatives of the flow map. The Biot-Savart kernel is regularized and the velocity is evaluated by a multipole treecode. The method is applied to compute the azimuthal instability of a vortex ring. Vorticity isosurfaces are investigated. Results are presented showing the deformation of the ring axis and the presence of local axial flow in the core of the ring as seen in experiments. We also found evidence that the local axial flow reverses direction similar to Naitoh experiments. (Received July 21, 2008)

1046-65-76 **Javed I. Siddique*** (jsiddiqu@gmu.edu), 4400, University Drive, MS: 3F2, Department of Mathematical Sciences, George Mason University, Fairfax, VA 22030, and **Daniel M. Anderson** (danders1@gmu.edu) and **Padmanabhan Seshaiyer** (pseshaiy@gmu.edu). *Mathematical modeling of blood-flow interaction with deformable arterial wall with applications in medicine.* Preliminary report.

In this work, we consider the mathematical and computational modeling of blood flow interactions with the arterial wall. The flow is modeled with non-newtonian effects that reflect the changes of viscosity in the blood stream. Within the arterial wall, coupled equations for the structural displacement and fluid velocity are derived via two-phase mixture theory. The coupled partial differential equations for the blood-flow and the arterial wall are then solved using suitable interface conditions between the fluid and deformable porous wall. The applications of the model to understand the rupture of aneurysms and the development of atherosclerosis will also be investigated. Stability and convergence results for the performance of the model will also be presented. (Received July 21, 2008)

1046-65-83 **Fred J. Hickernell*** (hickernell@iit.edu), Room E1-208, Applied Mathematics, Illinois Institute of Technology, 10 W. 32nd Street, Chicago, IL 60616. *Evaluating Options Whose Payoffs Depend on Continuously Monitored Asset Prices.*

The price of an option may be expressed as the expected value of the payoff function, which depends on the asset price. This expected value or integral is typically approximated by a sample average of the payoff over n asset price paths. If the payoff function depends only on the asset price at d times, then the option price is a d-dimensional integral. A more realistic model in many cases treats the payoff function as depending on a continuously monitored asset price. Then the option price is an infinite dimensional integral. For computational purposes one must still use a finite (d) dimensional approximation to this integral, but then one encounters the problem of choosing the dimension d relative to the sample size, n. In this talk an error analysis is presented that demonstrates how this choice should be made, given a budget of $N = nd$ computer operations. Computational examples are presented for simple random and low discrepancy sampling, the latter providing a faster convergence rate. (Received July 22, 2008)

1046-65-97 **Padmanabhan Seshaiyer*** (pseshaiy@gmu.edu), Mathematical Sciences, MS:3F2, 4400 University Drive, Science and Tech I, George Mason University, Fairfax, VA 22030, and **Eugenio Aulisa** and **Sandro Manservisi**. *Computational Methods for fluid-structure interaction problems.*

In this talk, we will present a robust multilevel computational methodology to study the behavior of a fully coupled fluid-structure interaction problem. The method relies on the domain decomposition characteristics of multigrid Vanka solvers, which decompose the complex global domain into finite element local sub-domains and then the global solution is computed iteratively. The method employs multigrid projection and restriction operators that are used to impose the matching between the extended fluid and solid velocity field. Stability and convergence of the proposed methodology will be investigated and presented. The numerical implementation on a multiprocessor architecture results in a straightforward and flexible algorithm. Numerical computations will be presented to validate the performance of the method for benchmark applications involving fluid-strucutre interaction. (Received July 22, 2008)

1046-65-132 **Weifu Fang** and **Suxing Zeng*** (sxzeng@math.wvu.edu), 121 Park street, Morgantown, WV 26501. *Numerical Solutions of Boundary Inverse Problems for the Laplace Equation.*

Based on a boundary integral equations formulation, we present numerical solutions for two inverse problems for the Robin boundary value problem for the Laplacian: (1) the inverse problem of recovering the Robin coefficient from a boundary measurement of the solution on a portion of the domain boundary, and (2) the inverse problem of recovering part of the Robin boundary from multiple sets of partial boundary measurements. (Received September 10, 2008)

1046-65-189 **Andrei Bourchtein*** (burstein@terra.com.br), Rua Anchieta 4715, bloco K, ap.304, Pelotas, RS 96015-420, Brazil, and **Ludmila Bourchtein**. *Application of splitting techniques in numerical models for a hydrostatic atmosphere.*

Complete 3D mathematical models of the atmosphere (Navier-Stokes or Euler equations) support solutions with very different time and space scales reflecting multi-scale nature of the atmosphere dynamics. Since the large-scale processes contain the main part of the atmosphere energy, for the problems of the numerical weather prediction or large-scale simulation, the complete governing equations can be considered as stiff systems containing insignificant gravity and acoustic waves.

Besides hydrostatic approximation filtering the fastest acoustic waves and keeping the principal physical processes quasi intact, there is no known differential approximation that contributes to elimination of the fast insignificant waves without distortion of the principal physical modes. In this way, the problem of scale separation should be addressed in numerical scheme design in order to achieve accurate and computationally efficient solution.

In this research we apply different splitting techniques to construct a numerical scheme for hydrostatic atmosphere which allows sufficiently large time steps based on accuracy considerations, provides efficient solution of algebraic equations arising at each time step, and assures required accuracy of the predicted atmospheric fields. (Received August 14, 2008)

1046-65-352 **Peng Ni*** (davisni@wpi.edu), 49 Institute Road, Apt 2, Worcester, MA 01609, and **Homer Walker** (walker@wpi.edu), **Chun Yang** (yangchun@bnu.edu.cn) and **Dalin Tang** (dtang@wpi.edu). *GMRES Algorithm in the Meshless Generalized Finite Difference Method for Human Carotid Atherosclerotic Plaque Progression Simulation.* Preliminary report.

Atherosclerotic plaque rupture and progression have been the focus of intensive investigations in recent years. Plaque rupture is closely related to most severe cardiovascular syndromes such as heart attack and stroke. A computational procedure based on meshless generalized finite difference (MGFD) method and serial magnetic resonance imaging (MRI) data was introduced to quantify patient-specific carotid atherosclerotic plaque growth functions and simulate plaque progression.

In this talk, we compare the MGFD method with the currently prevailing finite element method in ADINA. Also, we focus on the linear system embedded in the MGFD method, and introduce the Generalized Minimal Residual (GMRES) algorithm to solve it.

The results from MGFD and ADINA had good agreement (error $< 2\%$). The GMRES algorithm saved 53% CPU time compared to the Gaussian Elimination method for the case simulated. The saving will be critical for 3D models which need several hours/days to solve. The improved MGFD method will be used in further plaque progression simulations.

Acknowledgement: This research was supported by NSF grant DMS-0540684. MRI data was provided by Dr. Chun Yuan and his group from University of Washington Medical School. (Received August 27, 2008)

1046-65-353 **Zhimin Zhang**, 656 W. Kirby, #1131, Detroit, MI 48202, and **Huiqing Zhu*** (at7136@wayne.edu), 656 W. Kirby, #1118, Detroit, MI 48202. *Convergence Analysis of Mixed LDG Methods applied to 2-D singularly perturbed problems.*

The mixed scheme of local discontinuous Galerkin methods on 2-dimensional domain is analyzed for solving singularly convection-diffusion problems. Two types of numerical fluxes are chosen for the LDG scheme. An convergence rate in compact energy norm, which involves both the error of the gradient and the potential, is established under certain regularity assumptions. This convergence rate is $O(N^{-1.5})$ with respect to a certain ϵ, where $N \times N$ is the number of elements in each subdomains. Furthermore, under one more assumption about the numerical fluxes, an ϵ-uniform convergence rate $O((\ln \epsilon/N)^2)$ is verified. Numerical experiments verified the convergence behaviors. (Received August 27, 2008)

1046-65-402 **Michael Neilan*** (neilan@math.utk.edu), Department of Mathematics, 121 Ayres Hall, 1403 Circle Dr., Knoxville, TN 37996. *Finite element approximations of fully nonlinear second order PDEs.*

This talk concerns with numerical approximations of solutions of fully nonlinear second order partial differential equations. A new notion of weak solutions, called moment solutions, is introduced, which unlike viscosity solutions, are defined by a constructive method called the vanishing moment method. As an example, we focus on the Monge-Ampére equation, and introduce conforming C^1 finite element methods, mixed finite element methods, and nonconforming finite elements for this problem based on the vanishing moment method. We then show convergence results and computational examples. (Received August 31, 2008)

1046-65-435 **S. Pederson** and **M. Sambandham*** (msambandham@yahoo.com), Department of Mathematics, 830 Westview Dr, Morehouse College, Atlanta, GA 30314. *Numerical Solution of Hybrid Fractional Differential Equations.* Preliminary report.

We discuss the numerical solution of hybrid fractional differential equations. The method given uses piecewise application of a numerical method for fractional differential equations. A convergence result is proven when the underlying numerical method for fractional differential equations is one-step explicit and numerically stable. A numerical example is presented by solving a hybrid relaxation-oscillation equation which is under Grunwald-Letnikov fractional differentiation. The numerical solution is compared to the exact solution. (Received September 02, 2008)

1046-65-569 **Dianne P. O'Leary*** (oleary@cs.umd.edu), Computer Science Department, University of Maryland, College Park, MD 20742. *A Noisy Adiabatic Theorem and Implications for Quantum Computing.*

Quantum computing has the potential to solve numerical problems that are intractable using conventional computing. A brief introduction to quantum computing reveals that such systems are governed by Schrödinger's equation. The adiabatic theorem gives conditions that guarantee that such a system remains in its ground state when started in its ground state and evolved slowly. Realistically, such systems are subject to perturbations in the initial condition, systematic time-dependent perturbations in the Hamiltonian, coupling to low-energy quantum systems, and decoherent time-dependent perturbations in the Hamiltonian. Using Wilkinson-style perturbation analysis, we obtain bounds on the effects of these perturbations. This is joint work with Michael J. O'Hara. (Received September 08, 2008)

1046-65-577 **Rostam Sabeti*** (sabetiro@msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824-1027, and **Tien-Yien Li** (li@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824-1027. *On numerical-symbolic exact irreducible decomposition of cyclic-12.*

In 1992 Göran Björck and Ralf Fröberg completely characterized the solution set of cyclic-8. In 2001 Jean-Charles Faugére determined the solution set of cyclic-9 by computer algebra methods and Gröbner basis computation. In this talk, we present an algorithm based on theories and algorithms developed in **numerical algebraic geometry** as well as a novel idea that hybridizes symbolic and numerical techniques to derive **exactly** the defining polynomials of **all** prime ideals of positive dimension in primary decomposition of cyclic-12. (Received September 08, 2008)

1046-65-610 **Sergei V. Pereverzev*** (sergei.pereverzyev@oeaw.ac.at), Johann Radon Institute, Altenbergerstrasse 69, 4040 Linz, Austria. *Adaptive kernel methods using the balancing principle*

In Tikhonov type regularization methods an approximate solution for some ill-posed problem is constructed as a minimizer of the sum of a discrepancy and a penalty. Usually the form of a penalty term is assumed to be given a priori. In the context of Learning theory the use of Tikhonov regularization leads to the learning algorithm known as Regularization Networks. In this algorithm the penalty is usually the norm of some Reproducing Kernel Hilbert Space (RKHS), where one is looking for a learner. In several practically important applications the kernel generating RKHS-norm is not known a priori. In the talk we are going to discuss two approaches to a data-driven choice of a penalty in RKHS-based Tikhonov regularization. In both these approaches we use the Balancing principle for the choice of regularization parameter that recently attracts an attention in the Regularization theory.

The talk is based on the joint research with Ernesto De Vito (University of Genova), Lorenzo Rosasco (MIT) and Huajun Wang (Johann Radon Institute, Linz) (Received September 09, 2008)

1046-65-687 **Andrew Sommese*** (sommese@nd.edu), Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556-4618. *A Numerical Local Dimension Test for Algebraic Sets.*

This talk will discuss a recent numerical algorithm of Daniel Bates, Jonathan Hauenstein, Chris Peterson, and myself to compute the dimension at a point of the zero set X of a system of polynomials $f_1(z), \ldots, f_n(z)$ on $\mathbb{C}^N$, where N and n may be different. This algorithm allows effective computation of the irreducible decomposition of X for significantly larger n and N than current methods. (Received September 10, 2008)

1046-65-732 **Bo Dong*** (Bo_Dong@brown.edu), 182 George St, Box F, Providence, RI 02912, and **Chi-Wang Shu** (Chi-Wang_Shu@brown.edu), 182 George St, Box F, Providence, RI 02912. *Analysis of a local discontinuous Galerkin method for fourth-order time-dependent problems.*

We analyze a local discontinuous Galerkin (LDG) method for fourth-order time-dependent problems in one-dimensional and multidimensional spaces. Optimal convergence rates are obtained in one dimension and in two dimensions for Cartesian grids, and the results are extended to higher even order equations. For triangular meshes in multidimensional spaces, we prove optimal convergence results by using error estimates of the corresponding biharmonic problems, and the technique is extended to the linearized Cahn-Hilliard type equations. Numerical experiments are displayed to verify the theoretical results. (Received September 10, 2008)

1046-65-767 **Daniel B Szyld*** (szyld@temple.edu), Temple University, Department of Mathematics (038-16), 1806 North Broad Street, Philadelphia, PA 19122. *Application of inexact and truncated Krylov subspace methods to the solution of parabolic control problems.* Preliminary report.

We discuss the use of state-of-the-art Krylov Subspace Methods for the solution of certain large scale optimization problems governed by parabolic partial differential equations. We present recent results on inexact Krylov subspace methods, in which the matrix-vector product at each step does not need to be computed exactly. In fact, these products can be more and more inexact, as the iteration progresses. When the matrix in question is in product form with one or more implied solution of (inner) linear systems, these systems can be approximated less and less accurately as the iteration progresses. Computable inner stopping criteria were developed to guarantee convergence of the overall method. We will discuss these criteria, and illustrate its application to parabolic control problems, where the reduced Hessian has two different inverses; and thus two inner iteration criteria are needed. Truncated methods are also discussed. (Received September 11, 2008)

1046-65-795 **Xiaoming He*** (xiaoming@vt.edu), Department of Mathematics, Virginia Tech, Blacksburg, VA 24061, **Tao Lin** (tlin@vt.edu), Department of Mathematics, Virginia Tech, Blacksburg, VA 24061, and **Yanping Lin** (yanlin@ualberta.ca), Department of Mathematical and Statistics Sci, Edmonton, AB T6G 2G1, Canada. *A system of bilinear immersed finite elements.*

This presentation discusses a bilinear immersed finite element(IFE) space for solving second order elliptic boundary value problems with discontinuous coefficients (interface problem). This is a nonconforming finite element space and its partition can be independent of the interface. The error estimates for the interpolation of a Sobolev function indicate that this IFE space has the usual approximation capability expected from bilinear polynomials. Then this space is implemented to Galerkin method, finite volume element method and discontinuous Galerkin method. Numerical examples show that these methods have the same optimal convergence rates as those with standard bilinear finite elements. Some convergence analysis about these methods is also provided. In a word, we are trying to build a system of bilinear IFE which is similar to that of standard finite elements. Hopefully this system can be a solid base for the future work about IFE and its application. (Received September 11, 2008)

1046-65-877 **David L George*** (dgeorge@amath.washington.edu), U.S. Geological Survey, Cascades Volcano Observatory, 1300 SE Cardinal Court, Building 10, Suite 10, Vancouver, WA 98683. *Numerical methods and software for hazardous free-surface geophysical flows.*

A large class of hazardous geophysical flows involves a shallow free-surface mass flowing under the influence of gravity. Examples of such flows include river flooding, storm-surges, tsunamis, landslides, avalanches and similar debris flows. Often the movement and inundation of these flows onto “dry” land is the relavent physical feature of interest from a hazard modeling perspective. We model these types of flows with 2D depth-averaged equations, which makes large-scale computations tractable (such as modeling an entire ocean in the case of tsunami modeling.) All of these flows present similar difficulties from a numerical or computational perspective. First, they exhibit diverse spatial scales—meter or centimeter scale grids are often needed at the inundating front on a domain that might extend thousands of kilometers. Second, the boundaries of the flowing mass moves throughout the domain. Third, often dynamic features of the flow are due to a deviation of balanced steady-states that present well-known numerical difficulties. Lastly, these systems exhibit discontinuities and nonunique solutions indicative of hyperbolic systems. I will describe the numerical methods and software that we develop for these applications. (Received September 12, 2008)

1046-65-896 **Guohui Song*** (gusong@syr.edu), 215 Carnegie Building, Syracuse University, Syracuse, NY 13244. *Optimal Kernel via an Estimate to the Eigenvalues of Kernel Matrices.*

We study the problem of learning a real-valued function from Reproducing Kernel Hilbert Spaces by regularization. We establish a criterion for selecting the optimal kernel from a set of translation-invariant kernels. We show that, for equi-distant sample points, it leads to an optimization problem over an integral, which will reduce the computation complexity. Similar results can be extended to non equi-distant sample points. (Received September 12, 2008)

1046-65-906 **John E. Osborn*** (jeo@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *Generalized Finite Element Methods, Meshless Methods, and Quadrature.*

Generalized Finite Element Methods (GFEM) and Meshless Methods (MM) are the focus of considerable interest, especially in the engineering community. In this talk I will survey MM and GFEM, concentrating on basic ideas. It is widely recognized that creating effective quadrature schemes for GFEM and MM is an important problem (see, *e.g.,* A stabilized conforming nodal integration for Galerkin mesh free methods, J.-S. Chen, C.-T. Wu, S. Yoon, and Y. You, *Int. J. Numer. Meth. Engng.* 2001; **50**:435–466). I will discuss recent joint results with Ivo Babuška, Uday Banerjee, and Helen Li on quadrature schemes for MM. (Received September 12, 2008)

1046-65-948 **Patrice Koehl*** (koehl@cs.ucdavis.edu), Department of Computer Science, Genome Center, University of California, Davis, CA 95616, and **Joel Franklin**, **Seb Doniach** and **Marc Delarue**. *Fast Protein Dynamics Simulations: Dominant Pathways for Protein Conformational Transitions.*

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 12, 2008)

1046-65-959 **Raymond H Chan*** (rchan@math.cuhk.edu.hk), Department of Mathematics, The Chinese University of Hong Kong, Shatin, NT, Hong Kong. *Missing Data Recovery by Tight-frame Algorithms with Flexible Wavelet Shrinkage.*

The recovery of missing data from incomplete data is an essential part of any image processing procedures whether the final image is utilized for visual interpretation or for automatic analysis. In this talk, we first introduce our tightframe-based iterative algorithm for missing data recovery. By borrowing ideas from anisotropic regularization and diffusion, we can further improve the algorithm to handle edges better. The algorithm falls within the framework of forward-backward splitting methods in convex analysis and its convergence can hence be established. We illustrate its effectiveness in few main applications in image processing: inpainting, impulse noise removal, super-resolution image reconstruction, and video enhancement. (Received September 13, 2008)

1046-65-987 **Olga Drblikova** and **Angela Handlovicova*** (handlovicova@math.sk), Faculty of civil engineering SUT, Radlinskeho 11, 81368 Bratislava, Slovak Rep, and **Karol Mikula**. *Finite volume scheme for the nonlinear tensor anisotropic diffusion.*

Semi-implicit diamond-cell finite volume numerical scheme, for solving the nonlinear tensor anisotropic diffusion is investigated. The nonlinear tensor anisotropic diffusion introduced by Weickert is used in many image processing applications. First we present the finite volume scheme and its basic properties. Then the error estimate analysis is presented, where the piecewise constant approximation given by the finite volume scheme is compared with the weak solution to the problem. We proved that the error of the approximate solution in L^2-norm is of order

h, where h is a spatial resolution step under the natural relation $k \approx h^2$, where k is a time discretization step. (Received September 13, 2008)

1046-65-1000 **Tian-Xiao He*** (the@iwu.edu), Dept. Math. & CS, P. O. Box 2900, Illinois Wesleyan University, Bloomington, IL 61702-2900. *Spline Wavelets, Finite Element Wavelets, and Wavelets with Composite Dilation.* Preliminary report.

We present here some preliminary work for continuing and smoothing off the two-dimensional Haar-type composite wavelets. A comparison of the wavelets with composite dilation, spline wavelets, and finite element wavelets will be discussed. Finally, the advantages of one-dimensional composite wavelets and a brief application of wavelets with composite dilation in the numerical solution of differential equations will also be considered (Received September 13, 2008)

1046-65-1047 **Jie Shen*** (shen@math.purdue.edu), Department of Mathematics, Purdue University, West Lafayette, IN 47906. *A New Spectral-Galerkin Method for High-Dimensional PDEs.*

Many scientific, engineering and financial applications require solving high-dimensional PDEs. However, traditional tensor product based algorithms suffer from the so called "curse of dimensionality". We shall present a new spectral-Galerkin method for non-periodic problems and/or in the whole space. The method is based on two basic ingredients: (i) Choosing the frequencies of the trial functions from the "hyperbolic cross"; (ii) Using a lattice rule or sparse grid to perform the numerical integration. It is shown that with this combination, the "curse of dimensionality" can be broken to some extent. We shall present rigorous error estimates and numerical results supporting this statement. (Received September 14, 2008)

1046-65-1060 **Yingda Cheng*** (ycheng@math.utexas.edu), Department of Mathematics, University of Texas at Austin, Austin, TX 78712, and **Chi-Wang Shu**, Division of Applied Mathematics, Brown University, Providence, RI 02912. *Superconvergence of Discontinuous Galerkin Finite Element Solutions for Time-Dependent Problems.*

In this talk, we present the convergence study of the discontinuous Galerkin (DG) finite element solution for conservation laws when special fluxes are used. We prove that the DG solution will be superconvergent towards a particular projection of the exact solution with order $(k + 1.5)$ when piecewise P^k polynomials are used, if $k \geq 1$. This is a sharp estimate as shown by numerical experiments. We will also discuss the superconvergence of the local DG (LDG) method for convection-diffusion equations. (Received September 14, 2008)

1046-65-1205 **L. Ridgway Scott*** (ridg@uchicago.edu), University of Chicago, 1100 E. 58th Street, 258 Ryerson, Chicago, IL 60637. *The Mathematics of Scientific Software Automation.*

Software automation refers to the automatic generation of software. The benefits of software automation over manual programming include reduced cost of software development and improved reliability. The main requirement for software automation is having rules that guide the software generation process. Fortunately, the mathematics at the heart of scientific simulation can provide such rules.

Software automation is being used in diverse areas of scientific computation. We will review its use in signal processing, computational quantum chemistry, numerical linear algebra, and solution of partial differential equations. We will contrast this approach with the traditional approach using conventional programming languages.

We give some details regarding the finite element method for approximating the solution of partial differential equations. We review the FErari method for generation of finite element matrices and indicate some mathematical ideas that this work introduces. In particular, it requires the study of optimization in some novel discrete spaces. We show how this provides a model for the general problem of software automation.

This represents joint work with Peter Brune, Jeff Hammond, Robert Kirby, Matt Knepley and Andy Terrel. (Received September 15, 2008)

1046-65-1206 **Li-Lian Wang*** (lilian@ntu.edu.sg), Division of Mathematical Sciences, School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore, Singapore. *Generalized Prolate Spheroidal Wave Functions and Spectral Methods on Quasi-uniform Grids.*

The Slepian series (i.e., the prolate spheroidal wave functions of order zero) has been proven to be an optimal tool for approximating bandlimited functions. Recently, there has been a growing interest in developing methods, including spectral/spectral-element methods, wavelets and infinite elements, using the Slepian series basis functions, which exhibit some remarkable advantages over their polynomial-based counterparts.

In this talk, we will define a family of generalized prolate spheroidal wave functions (GPSWFs), which are orthogonal with respect to the Gegenbauer weight function $(1-x^2)^\alpha$. The GPSWFs generalize the Slepian series to order $\alpha > -1$, and can also be viewed as a generalization of the Gegenbauer polynomials, but oscillate more uniformly over $(-1,1)$. Two special cases: $\alpha = 0, -\frac{1}{2}$ are of particular importance, and the GPSWFs of order $-\frac{1}{2}$ are closely related to Mathieu functions, which form a natural basis functions for PDEs in elliptic geometries.

We will present some properties and a set of GPSWF approximation results. We will also develop spectral methods on quasi-uniform grids based on the GPSWFs, and discuss their applications to time-harmonic scattering problems. (Received September 15, 2008)

1046-65-1292 **Peter W Jones*** (jones@math.yale.edu), Mathematics Department, Yale University, 10 Hillhouse Ave., New Haven, CT 06510. *Scales and Geometry in Data Sets.*

We will describe different notions of scale in data sets and discuss some recent ideas for finding them. We will give several examples, including image processing and time series. We will also discuss how randomization algorithms can be used to detect various scales. (Received September 15, 2008)

1046-65-1320 **Xinfeng Liu*** (xliu1@math.uci.edu), Department of Mathematics, Rowland Hall 340, Irvine, CA 92697, and **Nie Qing** and **Lee Bardwell**. *Mathematical modeling and numerical simulations of cell signaling pathways.*

A class of proteins referred to as scaffolds are thought to play many important roles during cell signaling. A model of generic, spatially localized scaffold protein has been developed, and the model indicated that a scaffold protein could boost signaling locally while simultaneously suppressing signaling at a distance. The mathematical equations for modeling cell signaling pathways or other complex biological systems are stiff reaction diffusion equations. We have developed a compact integration factor method to solve these equations. The part of the stability constraint due to diffusion can totally be removed if the linear diffusions are treated exactly using integration (IF) or exponential time differencing (ETD) methods. The storage and computations for such numerical approaches are usually prohibitive even for a moderate spatial size in two or three dimensions. In the novel approach of compact integration factor method, the required memory and computational cost are dramatically reduced for both IF and ETD methods, thus saving computational resources. This novel approach has been incorporated with adaptive mesh refinement and excellent performance has been observed. (Received September 15, 2008)

1046-65-1351 **Katharine F Gurski*** (kgurski@howard.edu), Department of Mathematics, Howard University, Washington, DC 20059, and **Stephen O'Sullivan**, School of Mathematical Sciences, University College Dublin, Belfield, Dublin 4 , Ireland. *On the stability of a numerical scheme for a system of ordinary differential equations with a large skew-symmetric component.* Preliminary report.

We consider nonlinear systems of ordinary differential equations that may be discretized as $\mathbf{B^{n+1}} = (\mathbf{I} - \mathbf{\Delta t G^n})\,\mathbf{B^n}$. The real matrix $\mathbf{G^n}$ can be decomposed into symmetric, $\mathbf{P}$, and skew-symmetric, $\mathbf{S}$, components. This scheme is stable if the spectral radius $\rho(\mathbf{I} - \mathbf{\Delta t G^n}) < \mathbf{1}$. If the skew component becomes dominant, then the CFL stability condition requires the step size Δt to approach zero.

In this talk we wish to compare the stability of two related families of numerical schemes defined via the reference operators $\mathbf{P}$, $\mathbf{S}$, and the parameter θ ($0 \leq \theta \leq 1$). The first scheme is $\mathbf{G}'(\theta) = \mathbf{I} - \mathbf{\Delta t}(\mathbf{1}-\theta)\mathbf{P} - \mathbf{\Delta t}\theta\mathbf{S}$ and the second, $\mathbf{H}'(\theta)$, incorporates the predictor-corrector scheme along with multiplicative operator splitting.

We present upper bounds on the CFL condition that show that the time step for the $\mathbf{H}'(\theta)$ is greater or equal to the time step for $\mathbf{G}'(\theta)$ and that $\mathbf{H}'(\theta)$ is stable for $0 \leq \theta \leq 1$ unlike $\mathbf{G}'(\theta)$. (Received September 15, 2008)

1046-65-1460 **Abdramane Serme*** (aserme@bmcc.cuny.edu) and **Lucio M.G. Prado** (lprado@bmcc.cuny.edu), Department of Mathematics - BMCC - The City, University of New York, 199 Chambers Street, New York, NY 10007-1097. *The Schur Aggregation and Ill Conditioned Linear System.*

The talk is about solving ill conditioned linear system $Ax = b$ by the approach of the Schur aggregation.It is well known that its accurate solution $x = A^{-1}b$ can be computed readily if the linear system is well conditioned but the computation requires special care if the system is ill conditioned. The Schur aggregation is the process of reducing the linear system $Ax = b$ using the SMW (Sherman-Morrison-Woodbury) formula
$A^{-1} = (C - UV^H)^{-1} = C^{-1} + C^{-1}U(I_r - V^H C^{-1}U)^{-1}V^H C^{-1}$.
We essentially reduce the computation of $x = A^{-1}b$ to the computation of the Schur aggregate $S = I_r - V^H C^{-1}U$. We will also discuss additive preconditioning $A \to C = A + UV^H$ for preconditioner UV^H of a smaller rank r. (Received September 15, 2008)

1046-65-1472 **Stephen D Bond*** (sdbond@illinois.edu), Department of Computer Science, University of Illinois, 201 N Goodwin Ave, Urbana, IL 61801, and **Burak Aksoylu**, **Eric C Cyr** and **Michael J Holst**. *Goal-Oriented Error Estimation and Multilevel Preconditioning for the Poisson-Boltzmann Equation.*

The computation of "free energy" has been described as one of the most important and challenging problems in computational chemistry. Free energy is the thermodynamic state function which describes the macroscopic properties of a system and, hence, plays an integral role in multiscale modeling and coarse-grained simulation. One of the most popular coarse-graining methods approximates the solvent (e.g., water) interactions by a dielectric continuum as described by the Poisson-Boltzmann equation (a nonlinear elliptic PDE). To calculate the "solvation free energy" for the coarse grained system, one must evaluate a linear functional of the solution to this PDE. In this talk, we show how one can calculate the solvation free energy using an adaptive finite element approximation to the solution of the Poisson-Boltzmann equation. In our scheme, the mesh refinement is driven by goal-oriented error estimation based on the free energy functional. Hierarchical basis methods are used to precondition the resulting algebraic systems arising in the multilevel finite element discretization. (Received September 15, 2008)

1046-65-1531 **Yulong Xing*** (xing@cims.nyu.edu), 251 mercer street, New York University, new york, NY 10012, and **Andrew J. Majda** and **Wojciech W. Grabowski**. *New Efficient Sparse Space-Time Algorithms for Superparameterization on Mesoscales.*

Superparameterization (SP) is a multi-scale modeling system with explicit representation of small-scale and mesoscale processes provided by a cloud-resolving model (CRM) embedded in each column of a large-scale model. The approach involves applying a 2D cloud-resolving model in each column of a 3D large-scale model. In the original formulation, small scale models are solved through the whole time and over the whole domain. Here we present new efficient sparse space-time algorithms based on the original idea of SP, which only solve the small scale models in some reduced portion of the spatial domain and time interval, while we keep the same large scale dynamics. The new algorithms have been applied to a two-dimensional free squall line test, and the numerical results are compared with the CRM and original SP test. It shows that the large scale variables, such as velocity and specific humidity, can be captured in a reasonably statistically accurate way, based on the information passed from the reduced small scale models for space-time domains reduced by roughly a factor of 1/3; thus, the new efficient algorithms for SP result in a gain of roughly a factor of 10 in efficiency and a statistical accuracy on the large scale variables. (Received September 15, 2008)

1046-65-1555 **Edmond Nadler*** (enadler@emich.edu), Department of Mathematics, Eastern Michigan University, Ypsilanti, MI 48197. *Approximation by Bivariate Linear Splines for Adaptive Mesh Generation.*

An early work in the analysis of adaptive mesh generation was [Nadler 1985]. 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, the above results are reviewed and extended to the more useful cases of *continuous* linear (approximating) splines and *interpolating* linear splines. (Received September 16, 2008)

1046-65-1588 **Akil Narayan*** (anaray@dam.brown.edu), Division of Applied Mathematics, Box F, 182 George Street, Providence, RI 02912. *Jacobi-Gauss quadrature and near-optimal Lebesgue constants.* Preliminary report.

The $O(logN)$ asymptotic value of the Lebesgue Constant for polynomial interpolation on a finite interval has been well-established. However, the search for nodal sets that minimize the Lebesgue Constant is still ongoing. In particular, the Chebyshev nodal set is known to have near-optimal Lebesgue Constant. In this work we present findings that indicate that the Gauss quadrature nodes associated with particular classes of Jacobi polynomials are markedly closer to Lebesgue-optimal than the Chebyshev nodes. Furthermore, we present an $O(N^2)$ algorithm (which involves the Golub-Welsch Gauss quadrature algorithm) for determining these nodes given N. (Received September 16, 2008)

1046-65-1609 **Jin Wang***, Department of Mathematics and Statistics, Old Dominion University, Norfolk, VA 23529, and **Gene Hou**. *A numerical method for constrained dynamic problems.* Preliminary report.

We formulate a numerical model to solve a class of constrained dynamic systems which consist of differential-algebraic equations. A decoupled, iterative procedure is introduced, and an error analysis is presented. We will

also discuss some computational results, as well as applications, of this numerical model. (Received September 16, 2008)

1046-65-1656 **Qiya Hu** (hqy@lsec.cc.ac.cn), ISEC, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Beijing, 100080, Peoples Rep of China, **Jinchao Xu** (xu@math.psu.edu), Department of Mathematics, Penn State University, University Park, PA 16802, and **Bin Zheng*** (zheng@math.psu.edu), Department of Mathematics, Penn State University, University Park, PA 16802. *New Finite Element Methods for Fourth Order Curl Equations.*

Developing accurate and efficient numerical approximations of solutions of high order PDEs is a challenging research topic. There are several difficulties that may be encountered in the finite element approximations of high order PDEs. For example, the conforming finite element methods would require high smoothness of the approximating functions and a large number of degrees of freedom, thus increasing the computational cost significantly. An alternative approach is to use nonconforming methods.

This talk will present two new finite element methods that directly discretize the fourth order curl equations (involving $(\nabla\times)^4$) in three dimensions arising from magnetohydrodynamics (MHD) models. These elements provide nonconforming approximations for which the number of degrees of freedom is very small. The inter-element continuity is imposed weakly along the tangential directions which is appropriate for the approximation of the magnetic field. We will also show the detailed construction of basis functions and optimal error estimates for model problems containing both second order and fourth order terms. (Received September 16, 2008)

1046-65-1662 **X. Yang*** (xfyang@email.unc.edu), CB#3250, Phillips Hall, Chapel hill, NC 27599, **Gregory M Forest** (forest@amath.unc.edu), CB3250 Phillips hall, Chapel hill, NC 27599, **William M. Mullins** (mullins@email.unc.edu), CB#3250 Phillips Hall, Chapel hill, NC 27599, and **Qi Wang** (qwang@math.sc.edu), Univ of South Caroina, Columbia, SC 29208. *Dynamic defect morphology of sheared nematic polymers.*

The standard approach of defect characterization in liquid crystals and nematic polymers begins with the detection of topology from texture snapshots. Then one probes into the defect core to resolve the apparent discontinuity of the principal axis of orientation. However, it is time consuming and prohibitive to track the topological changes when the defects are created or annihilated. Instead, we focus on the detection of disordered phase in the core which are defined by local algebraic conditions on the eigenvalues of the second-moment tensor. The local disordered phases do not only exist for higher space dimensions, 2-d or 3-d, but also 0-d and 1-d. To illustrate these detection and tracking tools which are implemented automatically by the level set methods, we present the flow-orientation simulations in 2-d, where the topological defects and order degeneracy defects co-exist. In summary, local algebraic metrics clearly trump topology with respect to cost, detection, tracking of defects. (Received September 16, 2008)

1046-65-1861 **Susanne C. Brenner** (brenner@math.lsu.edu), Center for Computation and Technology, Johnston Hall, Louisiana State University, Baton Rouge, LA 70803, **Thirupathi Gudi*** (tgudi@cct.lsu.edu), Center for Computation and Technology, Jonston Hall, Louisiana State University, Baton Rouge, LA 70803, and **Li-yeng Sung** (sung@math.lsu.edu), Department of Mathematics, Lockett Hall, Louisiana State University, Baton Rouge, LA 70803. *A C^0 Interior Penalty Approximation of the Cahn-Hilliard Equation in Phase Separation.*

C^0 Interior Penalty method is an attractive alternative for the numerical approximation of fourth order problems. It is based on C^0 finite element spaces and an interior penalty on the jumps of the normal derivatives over the skeleton of the finite element mesh. In this talk, I will present some theoretical and numerical results related to the numerical approximation of the Cahn-Hilliard equation by a C^0 interior penalty method. This is joint work with Professor Susanne C. Brenner and Professor Li-yeng Sung. (Received September 16, 2008)

1046-65-1868 **Yuen-Yick Kwan*** (tkwan@tulane.edu) and **Jie Shen** (shen@math.purdue.edu). *A new spectral-element method in polar and spherical geometries.* Preliminary report.

When solving differential equations in a unit disk or cylinder, it is common to apply Fourier transform to the azimuthal direction to reduce the dimension of the problem. When a tensor-grid is used, the same number of Fourier modes is used in the whole disk. This may not be optimal since the function may oscillate less on a circle near the pole than on one away from the pole. To achieve uniform resolution, the number of Fourier modes used should increase as the distance from the pole increases.

Similar situation appears when solving equations on the surface of sphere, where it is common to apply the Fourier transform in the longitudinal direction. Different discretizations may be used in the latitudinal direction. Though spherical harmonics can provide uniform resolution on the sphere, the transforms involved are complicated and expensive. On the other hand, other methods may not provide uniform resolution.

We present a new method to approximate functions in the unit disk and on the surface of sphere, in which more Fourier modes are used as the distance from the pole increases. The method can provide uniform resolution and uses collocation points that are more uniformly-distributed than traditional methods. (Received September 16, 2008)

1046-65-1885 **Danko Adrovic** (adrovic@math.uic.edu), University of Illinois at Chicago, Dept. of Math, Stat & CS, 851 S. Morgan St. (m/c 249), Chicago, IL 60607-7045, and **Jan Verschelde*** (jan@math.uic.edu), University of Illinois at Chicago, Dept. of Math, Stat & CS, 851 S. Morgan St. (m/c 249), Chicago, IL 60607-7045. *Polyhedral Methods to find Common Factors of Algebraic Plane Curves.* Preliminary report.

Deciding whether two polynomials in two variables with approximate coefficients have a common factor is a problem in symbolic-numeric computing. The tropical viewpoint leads us to compute tropisms. Tropisms define initial forms of the polynomials which have common roots. These common roots are the initial coefficients of the Puiseux series used to grow to representation of the common factor. The algorithms we use to compute tropisms and coefficients of the Puiseux series lead to an efficient symbolic-numeric preprocessing method to decide whether two polynomials share a common factor. (Received September 16, 2008)

1046-65-1904 **Bjorn Engquist*** (engquist@math.utexas.edu), Departnent of Mathematics, University of Texas at Austin, 1 University Station C1200, Austin, TX 78712-0257. *Multiscale modeling of rare events with applications in biology.*

The heterogeneous multi-scale method is a framework for developing and analyzing numerical methods that couple computations from very different scales in space and time. We will present this framework and apply it to processes on cell and molecular scales that either generate rare events or relatively slow dynamics. (Received September 16, 2008)

1046-65-1910 **Yangsuk Ko*** (yko@csub.edu), Department of Mathematics, CSUB, 9001 Stockdale Highway, Bakersfield, CA 93311. *Higher Order Convergence of an SDG method for Scalar Conservation Laws.* Preliminary report.

In 2004, Palaniappan, Haber, and Jerrard introduced a new promising space-time discontinuous Galerkin (SDG) method for scalar conservation laws. Since then, L^1 estimates and entropy inequalities of the approximate solutions of the SDG method have been done and from these results, basic convergence results such as $h^{\frac{1}{4}}$ convergence rate of the approximate solutions of the SDG method were established. In this presentation, the stability results of high order approximate solutions of the SDG method and certain conditions which guarantee the convergence of these high order approximate solutions will be discussed. (Received September 16, 2008)

1046-65-1935 **F. Olcay Ilicasu*** (ilicasu@rowan.edu), Mathematics Department, 201 Mullica Hill Road, Glassboro, NJ 08028, and **David H Schultz** and **Bakhadirzhon Siddikov**. *Developing 3rd, 4th and 5th order Difference Techniques on a Singular Perturbation Problem and Their Stability Comparison.* Preliminary report.

A one-dimensional convection-diffusion equation

$$-\epsilon y''(x) + u(x)y'(x) = f(x), y(0) = \alpha, y(1) = \beta, \tag{1}$$

where $0 < \epsilon << 1$ is a constant,$u(x) \equiv 1$,and α, β are real numbers,is considered.From (1),

$$u''(x) - \omega u'(x) + \omega f(x) = 0, where \omega = 1/\epsilon. \tag{2}$$

3 points are used to develop a 3rd order method to approximate the lhs of(2)as in

$$u''(x_i) - \omega u'(x_i) + \omega f(x_i) = \alpha_i y_i + \alpha_{i+1} y_{i+1} + \alpha_{i-1} y_{i-1} + \beta_i \tag{3}$$

For the third order technique,we expand y_{i+1} & y_{i-1}in Taylor Series around x_i up to the 4th derivative term.

$$\begin{aligned} LHS = \alpha_i y_i + \alpha_{i+1}\{y_i + hy_i' + \frac{h^2}{2}y_i'' + \frac{h^3}{6}y_i''' + \frac{h^4}{24}y^{iv} + \ldots\} \\ \alpha_{i-1}\{y_i - hy_i' + \frac{h^2}{2}y_i'' - \frac{h^3}{6}y_i''' + \frac{h^4}{24}y^{iv} + \ldots\} + \beta_i. \end{aligned} \tag{4}$$

From (2), y_i'' is written in terms of lower order derivatives.For the 4th and 5th order methods, we consider the next derivative terms in Taylor expansions and proceed in a similar manner.Finally, we apply these techniques on 2 test problems and compare stability. (Received September 16, 2008)

1046-65-1956 **Ching-Shan Chou*** (cschou@math.uci.edu), Department of Mathematics, 340 Rowland Hall, University of California, Irvine, Irvine, CA 92697. *Computation of Spatial Dynamics in Systems Biology.*

Mathematical biology has been an emerging subject in recent years. Numerous models were proposed and computer simulation was extensively used to investigate the models. In particular, spatial dynamics is one of subjects that are of great interest. For example, morphogenesis in early embryo development, which is concerned with positions of the various specialized cell type, can be modeled by a systems of reaction-diffusion equations. Therefore, PDE systems play a critical role in modeling spatial dynamics of biological systems, and due to the difficulties in mathematical analysis of many systems, numerical simulations are the most important tools for model exploration.

In this talk, a few spatial models of PDEs in systems biology will be introduced. Each system presents different computational challenges, depending on the type of PDEs they belong to. The purpose of this talk is to bridge the design of numerical algorithm with the needs in specific applications, and discuss the possible future directions of numerical schemes in math biology. (Received September 16, 2008)

1046-65-2025 **Gunay Dogan*** (gunay.dogan@nist.gov), 100 Bureau Drive, Stop 8910, Gaithersburg, MD 20899-8910, and **George Biros**. *A fast inversion algorithm for linearized diffuse optical tomography with large data sets.* Preliminary report.

Diffuse optical tomography is an emerging imaging technology with great potential for breast and brain imaging. Sources of visible light are used to illuminate the body and images are inferred from outside measurements of the light that has diffused in the body. The reconstruction of images requires the solution of an ill-posed nonlinear inverse problem, which is usually computationally-intensive. In our work, we propose a fast method to compute 2d image reconstructions in the case of a large amount of measurements, when the inversion becomes even more demanding in terms of computation. We consider a square geometry where the light sources and measurements are located regularly on opposite sides of the domain, and solve a linearized version of the problem based on the Born approximation. By revealing the special structure of the problem, we design fast methods to assemble the coefficient matrix for the linearized problem. We also propose fast matrix-vector product routines that can be used to solve the linear system with iterative methods or sparse SVD. Finally we introduce a fast inversion algorithm that produces the solution of the inverse problem by solving a sequence of small systems. We demonstrate the effectiveness of our method with several examples. (Received September 16, 2008)

1046-65-2047 **Jeremy Wade*** (jwade@uoregon.edu), University of Oregon, Department of Mathematics, Eugene, OR 97403. *On the orthogonal expansion of functions on the cylinder.*

We present results on the (c, δ)-summability of the orthogonal expansion of a continuous function on the cylinder, $B^d \times [-1, 1]^m$, in terms of multi-variable orthogonal polynomials. In addition, we will present results on a reconstruction algorithm for functions on $B^2 \times [-1, 1]$ from Radon projections. (Received September 16, 2008)

1046-65-2115 **Yin Lu Young*** (yyoung@princeton.edu), Dept. of Civil and Environmental Engineering, E-326, Princeton University, Princeton, NJ 08540, and **Margot Gerritsen** (margot.gerritsen@stanford.edu), 367 Panama Street, Department of Energy Resources Engineering, Stanford University, Stanford, CA 94305. *Marine Energy Technology: Riding the current.*

In search for cleaner, greener, and more reliable energy resources, the ocean is not left unexplored. Tidal turbines can extract energy from currents similar to the way wind turbines extract energy from airflows. Although the typical operating flow speed of tidal turbines is only one sixth of wind turbines, the power density is three times higher. The higher loads meant the blades may be subject to strength, fatigue, and stall problems. Tidal currents are bi-directional, and exhibit spatially and temporally variations due to the tidal boundary layer and interactions with waves and nearby boundaries. Another challenge with tidal turbines is cavitation, which can cause undesirable effects such as performance decay, erosion, noise, and vibration. In this work, we will present a 3-D panel method for the transient analysis of current turbines subject to spatially varying flows with consideration to fluid cavitation. To ensure structural integrity, the panel method is coupled with a 3-D finite element method to examine the blade stresses and dynamic characteristics. The formulation, numerical implementation, and sample results are shown. Plans to couple the method with a depth-integrated tidal flow model will also be presented. (Received September 18, 2008)

1046-65-2117 **Max Gunzburger*** (gunzburg@fsu.edu), Department of Scientific Computing, DSL400, Florida State University, Tallahassee, FL 32306-4120. *Experiences in computational science and the Department of Scientific Computing at FSU*

We review our own experiences as a computational scientists,

highlighting how basic research in algorithms allow one to work in and
impact diverse applications areas. The particular algorithmic classes
we touch on are finite element methods, centroidal Voronoi tessellations, and PDE constrained optimization. The application areas
include aerodynamics, superconductivity, climate modeling, and groundwater flows. We then turn our attention to how to best train computational scientists, leading us to describe the missions and degree programs of the new Department of Scientific Computing at Florida State University. (Received September 19, 2008)

68 ► Computer science

1046-68-387 **Benjamin Rossman*** (brossman@theory.csail.mit.edu), Room G636, The Stata Center, Cambridge, MA 02139. *k-Clique Requires k/4 Variables.*

Using techniques from random graph theory and circuit complexity, we prove that k/4 variables are required to define the class of ordered graphs containing a k-clique in first-order logic. (Received August 29, 2008)

1046-68-464 **Atri Rudra*** (atri@cse.buffalo.edu). *Efficient List Decoding of Explicit Codes with Optimal Redundancy.*

Suppose you want to communicate k packets over a noisy communication channel. In order to tolerate errors, you transmit a redundant collection of $n = ck$ packets for some constant $c > 1$. When can you communicate reliably despite the adverse effects of the noisy channel? That is, when can the receiver recover the original message even in the presence of corrupted packets?

Clearly, the receiver must receive at least k correct packets to have any hope of recovering the original message. In this talk, I will describe an efficient encoding (and decoding) scheme that achieves this information theoretical limit: for any $\epsilon > 0$, the receiver can recover the original message as long as $(1 + \epsilon)k$ packets are not corrupted. The location of the correct packets and the errors can be chosen adversarially by the channel.

This achieves the optimal trade-off between redundancy and error-resilience for a malicious noise model where the channel can corrupt the transmitted symbols arbitrarily subject to a bound on the total number of errors. These results are obtained in an error-recovery model called list decoding.

The talk is based on a joint work with Venkat Guruswami (U. of Washington) (IEEE Trans. on Inf. Th. 08/STOC 06) (Received September 03, 2008)

1046-68-474 **Valerio Pascucci*** (pascucci@acm.org). *Multi-Scale Morse Theory for Scientific Data Analysis.* Preliminary report.

Advanced techniques for understanding large scale scientific data are a crucial ingredient in modern science discovery. Developing such techniques involves a number of major challenges in management of massive data and quantitative analysis of scientific features of unprecedented complexity. Addressing these challenges requires interdisciplinary research in diverse topics including the mathematical foundations of data representations, algorithmic design, and the integration with applications in physics, biology, or medicine.

In this talk, I will present a discrete topological framework for the representation and analysis of large-scale scientific data. Due to the combinatorial nature of this framework, we can implement the core constructs of Morse theory without the approximations and instabilities of classical numerical techniques. We use topological cancellations to build multi-scale representations that capture local and global trends present in the data. The inherent robustness of our combinatorial algorithms allows us to address the high complexity of the feature extraction problem for high-resolution scientific data.

I will conclude the talk discussing the effectiveness of our approach in a number of practical examples. (Received September 04, 2008)

1046-68-718 **Amber M Rogers*** (Rogersa2@nku.edu), Department of Mathmatics, Northern Kentucky University, Highland Heights, KY 41099, and **Brad Fox**. *Investigating KeeLoq.*

The KeeLoq block cipher is used for keyless entry by several popular car dealerships, such as Ford and GM. The cipher has been criticized for being insecure but many major car companies still use it. This talk will show the strengths and weakness of the cipher as well as highlight the attacks that have been implemented again the cipher. (Received September 10, 2008)

1046-68-735 **Delaram Kahrobaei*** (dkahrobaei@gc.cuny.edu), Doctoral Program in Computer Science, CUNY Graduate Center, 365 Fifth Avenue, New York, NY 10016, and **Michael Anshel** (csmma@cs.ccny.cuny.edu), Department of Computer Science, City College of New York, 138th Street & Convent Ave, New York, NY 10031. *A Gateway to Group based Cryptography.* Preliminary report.

Group-based cryptography has emerged as an exciting interdisciplinary area (see [MSV]). Our purpose is to show polycyclic groups(see [S], [HEO], [EK], [KK]) offer a gateway to group based cryptography. We show how classical public-key algorithms can naturally be formulated with in the context of polycyclic groups, and test it, using the framework of group based cryptography.

[MSU] Myasnikov, Shpilrain, Ushakov, Group-based cryptography, Birkhauser, 2008.

[S]Segal, Polycyclic groups. Cambridge Tracts in Mathematics, 82. Cambridge University Press, Cambridge, 1983

[HEO]Holt, Eick, O'Brien, Handbook of computational group theory. Chapman & Hall, 2005

[EK] Eick, Kahrobaei, Polycyclic Groups: New Platform for Cryptology? 2004

[KK]Kahrobaei, Khan: Non-commutative Generalizations of El Gamal using Polycyclic Groups, Proceeding of IEEE, 2006 (Received September 10, 2008)

1046-68-860 **Jonathan Katz*** (jkatz@cs.umd.edu), Department of Computer Science, University of Maryland, A.V. Williams Building, College Park, MD 20742. *Public-Key Cryptography from a (Theoretical) Cryptographer's Perspective.*

Mathematicians and computer scientists often approach the field of cryptography very differently. The purpose of this talk is to introduce mathematicians to a theoretical cryptographer's view of cryptography, and specifically public-key encryption. I will survey the basic definitions and constructions, and highlight recent advances in the field and prominent open questions. (Received September 12, 2008)

1046-68-951 **Sergey Yekhanin*** (yekhanin@microsoft.com), 1065 La Avenida, Mountain View, CA 94043. *Locally decodable codes.*

A q-query Locally Decodable Code (LDC) is an error-correcting code that encodes n-bit messages x to codewords $C(x)$, such that one can probabilistically recover any bit x_i of the message by querying only $q \ll n$ bits of the codeword $C(x)$, even after some constant fraction of codeword bits has been corrupted. The goal of LDC related research is to minimize the length of such codes.

In this talk we review the current state of the art in locally decodable codes with emphasis on the recent breakthrough algebraic constructions. (Received September 12, 2008)

1046-68-1023 **Chokri Cherif*** (ccherif@bmcc.cuny.edu), BMCC/City University of New York, 199 Chambers Street, Room N532, New York, NY 10007, and **Avraham Goldstein** (agoldstein@bmcc.cuny.edu), BMCC/City University of New York, 199 Chambers Street, Room N777, New York, NY 10007. *The Inverse Fixed Point Theorem and Image Encoding.* Preliminary report.

Let W be a contraction on the complete metric space (E, d) with contractivity factor s and fixed point f. Let g be in E, the space of digital images, then $d(f, g) \leq (1/(1-s))d(g, W(g))$ (Collage Theorem). Thus, by minimizing the distance between g and $W(g)$ (the collage of the image), we hope to minimize the distance between the fixed point f and the given image g. Of course, if the value of s is close to 1, nothing ensures that this method provides a good approximation. Yet this was the original idea of Barnsley and most of the fractal based algorithms rely on the same approach. In this work we present 1) a classical construction based on interpolation techniques to construct W. A description of the PIFS (Partitioned Iterated Function System) and it's associated algorithm are presented where range blocks are encoded using linear combinations of domain blocks when a good match for a range block is not found; and 2) our construction of an operator W that guarantees better fidelity due to a better bound we put on $d(f, g)$, without any cost on compression. A detailed analytic description of the operator as well as a complete algorithm are presented. (Received September 14, 2008)

1046-68-1397 **Aleksandar Donev*** (donev1@llnl.gov), P.O.Box 808, L-367, Livermore, CA 94551-9900. *Asynchronous Event-Driven Particle Algorithms in Computational Materials Science.*

I will present, in a unifying way, the main components of asynchronous event-driven (AED) algorithms for simulating physical systems of interacting particles [arXiv:cs/0703096]. Event-driven algorithms are not as widely used as time-driven algorithms even though they offer substantial efficiency improvements for a variety of algorithms. I will briefly sketch two examples where AED algorithms have proven to be vastly superior to more traditional alternatives: the well-known hard-particle Molecular Dynamics, as well as a recently-developed diffusion Kinetic Monte Carlo algorithm.

Note: This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344 (LLNL-ABS-406946). (Received September 15, 2008)

1046-68-1496 **Alexander V Ushakov*** (sasha.ushakov@gmail.com), Castle Point on Hudson, Hoboken, NJ 07030, and **Jonathan Longrigg**. *Cryptanalysis of the shifted conjugacy authentication protocol.*

We present the first practical attack on the shifted conjugacy based authentication protocol. (Received September 15, 2008)

1046-68-1510 **Wei Dai*** (weidai07@uiuc.edu), Coordinated Science Laboratory #111, University of Illinois at Urbana-Champaign, 1308 West Main St., Urbana, IL 61801, and **Olgica Milenkovic** (milenkov@uiuc.edu), Coordinated Science Laboratory #126, University of Illinois at Urbana-Champaign, 1308 West Main St., Urbana, IL 61801. *Iterative Subspace Pursuit Decoding of Weighted Euclidean Superimposed Codes.*

We propose a new iterative algorithm, termed subspace pursuit (SP), for decoding of weighted Euclidean superimposed codes (WESCs). WESCs allow for unique identification of small subsets of codewords based on their superposition, and therefore can be viewed as a specialization of compressive sensing schemes. Motivated by various algorithms for compressive sensing reconstruction, we propose the SP algorithm that has both small computational complexity and high decoding accuracy. Our analysis shows that accurate decoding is guaranteed as long as the codeword matrix satisfies the restricted isometry property with a constant parameter. Also presented is an upper bound on the computational complexity of the algorithm. (Received September 15, 2008)

1046-68-1571 **Gilles Villard*** (Gilles.Villard@ens-lyon.fr), Laboratoire LIP, 46 Allee d'Italie, F69364 Lyon Cedex07, France. *Numerical analysis tools for LLL lattice basis reduction.* Preliminary report.

LLL-reduction of lattice bases is an important algorithm [Lenstra, Lenstra, Lovàsz 1982] in computer science and mathematics making worthwile efficiency improvements.

A key ingredient of currently fastest reduction algorithms is using floating point approximations of rational numbers involved in the underlying Gram-Schmidt orthogonalisation (for integer bases). We especially refer to Schnorr's algorithms, and to the L2 Algorithm of Nguyen and Stehlé.

Revisiting and improving classical tools from the field of numerical analysis, such as QR perturbation analyses, we strengthen Schnorr's and the L2 approach, design a LLL-reduceness certificate, and propose a new algorithm for improving the quality of LLL-reduced bases. We describe these developments, and show in particular how floating point computations may be introduced at various levels in the overall reduction process.

This research is done in collaboration with I. Morel (U. Lyon, U. Sydney), and D. Stehlé (CNRS, Macquarie U., U. Sydney). (Received September 16, 2008)

1046-68-1631 **Gunnar Carlsson*** (gunnar@math.stanford.edu), Department of Mathematics, Stanford University, Stanford, CA 94305. *Topology and data.*

We will discuss methods for analyzing the stability of qualitative properties of data sets, such as the presence of loops, cluster decompositions, etc. The methods will involve quiver representations, and constitute and application of theorems of P. Gabriel and V. Kac on certain quiver representations. We will show how barcode output, such as that which occurs in persistent homology, plays a different role in this setting. (Received September 16, 2008)

1046-68-1837 **Daniel S. Roche*** (droche@cs.uwaterloo.ca), School of Computer Science, University of Waterloo, 200 University Ave. W., Waterloo, ON N2L 6P7, Canada. *Fast Multiplication with Low Space Complexity.* Preliminary report.

The multiplication of arbitrary-precision integers and univariate polynomials over finite fields is one of the fundamental components of any computer algebra system. The classical algorithm has time complexity $O(n^2)$, but this has been improved on many times, first by Karatsuba/Ofman, and later by Toom/Cook, Schönhage/Strassen, Cantor/Kaltofen, and others. However, all of the "faster" multiplication algorithms require at least $O(n)$ auxiliary storage space for their implementation, whereas the classical algorithm can be implemented with $O(\log n)$ space.

We present new algorithms with the same time complexity as Karatsuba multiplication, that is, $O(n^{1.59})$, but with only $O(\log^2 n)$ auxiliary storage space required, as well as the space for the result. This is achieved by following the general divide-and-conquer scheme of Karatsuba, but with extra restrictions on the recursive calls, so that at each recursive step only a constant amount of extra words of memory are needed. We also present an FFT-based algorithm for multiplication which uses just $O(\log n)$ extra space, but unfortunately works only when the size of the output is a power of 2. (Received September 16, 2008)

1046-68-1973 **Antonio R. Nicolosi*** (nicolosi@cs.stevens.edu), Computer Science Department, Stevens Institute of Technology, Castle Point on Hudson, Hoboken, NJ 07030. *Average-Case vs. Generic-Case Complexity of Lattice Problems.* Preliminary report.

Lattice problems whose average-case complexity is connected to worst-case assumptions are appealing foundations for provably secure cryptosystems. A sharper understanding of their inherent hardness would enable more precise security analyses, thus resulting in more efficient cryptographic primitives.

In this talk, we review the landscape of the average-case complexity of lattice problems, sketch some of the technical tools employed in their analysis, and discuss our on-going efforts to assess their generic-case complexity. (Received September 16, 2008)

1046-68-1974 **Nelly Fazio*** (fazio@cs.ccny.cuny.edu), Department of Computer Science, The City College of New York, 160 Convent Ave, NAC 8/206, New York, NY 10031. *Bilinear Groups and Algebraic Cryptography.* Preliminary report.

The discovery of bilinear groups—that is, cryptographic groups equipped with a bilinear map—has enabled the resolution of long-standing open problems in cryptography, while at the same time opening the way to a variety of novel applications. Despite their power and versatility, however, essentially all known bilinear groups are based on the algebraic structure of a single mathematical construct, namely elliptic (or hyperelliptic) curves.

In this talk, we start by taking a closer look at how bilinearity can be exploited to achieve the range of cryptographic properties required by the many applications of bilinear groups. Next, we discuss some preliminary efforts in investigating the feasibility of constructing bilinear groups based on alternative algebraic structures in combinatorial group theory. (Received September 16, 2008)

1046-68-2132 **Paul Barford*** (pb@cs.wisc.edu), University of Wisconsin-Madison, 7393 Computer Science & Statistics, 1210 West Dayton Street, Madison, WI 53706. *Internet Topology Inference*

Understanding the Internet's structure through empirical measurements is important in the development of protocols, traffic engineering and troubleshooting, among other things. While prior studies of Internet topology have been based on active probe-based measurements, passive measurements of packet traffic offer the possibility of a greatly expanded perspective of Internet structure with much lower overhead. In this talk, we describe algorithms for inferring network structure from simple passive measurements of IP packet traffic. We describe algorithms that enable 1) traffic sources that share network paths to be clustered accurately without relying on IP address or autonomous system information, 2) topological structure to be inferred accurately with only a small number of active measurements, 3) missing information to be recovered, which is a serious challenge in the use of passive packet measurements. We demonstrate our techniques using a series of simulated topologies and empirical data sets. We also show the trade-offs between selectively applied active probes and the accuracy of the inferred topology between sources. Finally, we characterize the degree to which missing information can be recovered from passive measurements, which further enhances the accuracy of the inferred topologies. (Received October 02, 2008)

70 ► *Mechanics of particles and systems*

1046-70-256 **Elizabeth A Zollinger*** (zollingerea@hiram.edu), PO Box 233, Hiram, OH 44234. *A Family of Orbits in the Newtonian Three-Body Problem.*

Using variational techniques, I look at curves with three bodies of equal mass that have collinear initial position and, after a given time, end up in an isosceles configuration with a fixed amount of rotation. I find a family of periodic orbits extending from Meyer's classic extreme "comet" case to orbits where the "comet" passes close to both primaries. These orbits have the same topology which are deformed into each other without passing through collision. (Received August 24, 2008)

1046-70-549 **David A Long*** (dalong@ncsu.edu), **Anthony M Bloch**, **Jerrold E Marsden** and **Dmitry V Zenkov**. *Relaxed Matching for Stabilization of Mechanical Systems.*

The method of controlled Lagrangians is a technique for stabilizing relative equilibria of mechanical systems with symmetry. In this talk we discuss a modification to this technique that gives greater flexibility to the theory, making it applicable to a broader class of systems. This "relaxed matching" technique is demonstrated in the problem of the pendulum on a rotor arm. (Received September 07, 2008)

1046-70-881 **Keith S. Promislow*** (kpromisl@math.msu.edu), Dept. of Mathematics, Michigan State University, East Lansing, MI 48824. *Proton Conduction in Polymer Electrolyte Membranes.*

Polymer electrolyte membranes (PEMs) play a key role as proton conductors and reactant separators in PEM fuel cells. They are phase separated materials with a percolating, hysteretic nanoscale pore morphology. We describe a model for both the pore formation within the polymer and the conduction of protons within the network. In particular we propose a novel higher-order curvature driven flow for the network formation and pose this within an abstract framework of the functionalization of convex energies as a process which generically describes the formation of a percolating sub-structure within a background matrix. (Received September 12, 2008)

1046-70-1274 **Steven Benzel*** (sbenzel@berry.edu), Berry College, Deptartment of Mathematics, PO Box 5014, Mt Berry, GA 30149-5014. *Explicit Symplectic Integration of Compact Lie Poisson Systems.*

Let $\mathfrak{g}$ be the Lie algebra of a compact Lie group. We classify all polynomial functions $h : \mathfrak{g}^\star \to \mathbb{R}$ such that the assignment $\xi \mapsto exp(tdh(\xi)) \cdot \xi$ is a canonical transformation for all $t \in \mathbb{R}$ and $\xi \in \mathfrak{g}^\star$. This provides an explicit symplectic integrator for all polynomial hamiltonians for compact Lie Poisson systems. (Received September 15, 2008)

1046-70-1429 **Antonio Mastroberardino*** (axm62@psu.edu), Penn State Erie, The Behrend College, School of Science, 4205 College Drive, Erie, PA 16563-0203, and **Brian J Spencer**. *Three-dimensional equilibrium crystal shapes with corner energy regularization.*

The evolution equations of crystal growth often employ a regularization of the surface energy based on a corner energy term. Here we consider the effect of this regularization on the equilibrium shape of a solid particle in three dimensions. We determine that a sufficient regularization involves only one of the two isotropic invariants related to curvature. Using a long-wave approximation, we derive a nonlinear equation for the shape of a semi-infinite wedge in the case when the surface energy has cubic symmetry. An analytic description of the solution along an edge is given as well as an exact solution for a special case of anisotropy. Finally, this equation is solved numerically to demonstrate explicit solutions for which the regularization rounds the edges of the unregularized crystal shape. (Received September 15, 2008)

74 ► Mechanics of deformable solids

1046-74-225 **Yanzhi Zhang*** (yzhang@scs.fsu.edu), Deparment of Scientific Computing, Florida State University, 400 Dirac Science Library, Tallahassee, FL 32306-4120, and **Max Gunzburger** (gunzburg@scs.fsu.edu). *Quadrature-rule type approximations to the quasicontinuum method.*

Quasicontinuum method using representative particles provides a simplified model to study huge molecular systems. However, its calculation still involves operations over all particles so that it does not essentially reduce the computational cost. The objective of this study is to develop quadrature-rule type approximations to further simplify the quasicontinuum method. For both short and long-range interatomic interactions, the complexity of the quadrature-rule type method depends on the number of representative particles but not on the total number of particles. Numerical experiments illustrate that the quadrature-rule type method is efficient and that it preserves much of accuracy of the quasicontinuum method. In fact, for the same computational cost, the quadrature-rule type approximation produces more accurate results than the quasicontinuum method.

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1046-74-809 **Aaron A. Allen*** (aaallen@iastate.edu), 245 Sinclair Ave. #322, Ames, IA 50014, and **Scott W. Hansen**. *Stability Results for a Multilayer Mead-Markus Beam.*

The classical Mead-Markus sandwich beam consists of two stiff beam layers which sandwich a beam compliant layer. We consider a multilayer generalization of this model consisting of $m + 1$ stiff layers bound together by m shear deformable layers with linear viscous shear damping included. We show that the semigroup associated with the multilayer beam is analytic. Furthermore, the angle of analyticity is described explicitly. A solution to the problem of how to optimally choose the damping in each layer to maximize the angle of analyticity is described. (Received September 11, 2008)

1046-74-1243 **Jay Benziger*** (benziger@princeton.edu), Dept. of Chemical Engineering, Engineering Quadrangle, Princeton University, Princeton, NJ 08544. *Non-linear Dynamics of Transport and Mechanical Properties in PEM Fuel Cells.*

Non-linear changes in the transport and mechanical properties of polymer electrolytes in fuel cells gives rise to unusual non-linear dynamical behavior of multiple steady states and current density front propagation in PEM fuel cells. We demonstrate that water in PEM fuel cells is conceptually identical to temperature in flames! Current ignition in PEM fuel cells is analogous to thermal ignition in flames, current density fronts propagate due to a balance between convection and diffusion as seen with flame fronts. Mechanical properties of polymer electrolytes play a key role in the dynamics of PEM fuel cells. The mechanical properties of Nafion (elastic modulus and creep rate) show a complex behavior as functions of water activity and temperature. The elastic modulus goes through a maximum and creep rate goes through a minimum at intermediate water activity that depends on temperature. Water and temperature cause microphase structural changes in Nafion that alter the mechanical and transport properties of Nafion. In this talk we shall examine the complex dynamics associated with mechanical and transport properties in Nafion and their implications for PEM fuel cell operation.
(Received September 15, 2008)

1046-74-1314 **Janet Chen Daniel**, **Anthony Tongen**, **Paul G Warne** and **Debra Polignone Warne*** (warneda@jmu.edu), Department of Mathematics & Statistics, MSC 1911, James Madison University, Harrisonburg, VA 22807. *A 3-D Nonlinear Anisotropic Elastodynamic Model for Rapid Enlargement of Intracranial Saccular Aneurysms.* Preliminary report.

Cerebral aneurysms are essentially a blood-filled ballooning out of the artery wall. The major catalyst for biomechanical modeling of intracranial saccular aneurysms has been the axisymmetric membrane treatments of Humphrey et al. We expand on the foundational membrane dynamics to develop a coupled fluid-solid-fluid (blood-aneurysm-cerebrospinal fluid) model from fully 3-D nonlinear elastic equations of motion and constitutive laws, with system coupling at both inner and outer fluid-aneurysm boundaries consistent with Navier-Stokes. Fundamental focal dilatations of the arterial wall due to biological forcing are explored. We derive the 3-D elastodynamics, employ strain-energies (including anisotropic arterial wall models), and determine governing nonlinear ordinary differential equations. We solve these numerically for comparison of lesion models in rapid enlargement. We observe aneurysm cyclic stretches, thickness changes, effects of material and geometric parameters, and through-the thickness stresses. More accurate assessment of treatment risks are critical in the medical dilemma of whether to monitor the patient for lesion changes or to surgically intervene as the consequences of rupture associated with spontaneous subarachnoid hemorrhage are devastating. (Received September 15, 2008)

1046-74-1714 **Tim McDevitt*** (mcdevittt@etown.edu), Dept of Mathematical and Computer Sciences, One Alpha Drive, Elizabethtown College, Elizabethtown, PA 17022. *Numerical Results for Energy Decay in Thermoelastic Beams.* Preliminary report.

Although heat conduction dissipates vibrations in thermoelastic beams, the application of additional damping mechanisms can speed stabilization. This talk presents numerical results that assess the relative importance of thermal effects and mechanical damping on the boundary by computing the spectra. Different models for thermoelastic beams will be considered. (Received September 16, 2008)

1046-74-1857 **Veerapaneni Shravan**, NY, and **Denis Gueyffier**, **George Biros** and **Denis Zorin*** (dzorin@cims.nyu.edu). *Numerical Simulation of Fluid Membranes in Stokesian flow.*

Stokesean fluid interacting with immersed deformable particles is a useful model for many applications. Examples include modeling of dynamics of bubbles and droplets, blood flow in small blood vessels and the dynamics of intra-cellular and extra-cellular vesicles. I will describe a fast solver for Stokes fluids interacting with deformable area-preserving membranes based on integro-differential problem formulation, which allows us to use degrees of freedom on boundaries only. Our solver combines high-order spatial discretization of membranes with FMM acceleration with novel preconditioning scheme and semi-implicit time-stepping scheme to resolve the membrane motion accurately and efficiently. I will discuss time-stepping and stability restrictions, and present numerical results that demonstrate the performance of the algorithm. (Received September 16, 2008)

76 ► Fluid mechanics

1046-76-235 **Yuri Antipov** and **Anna Zemlyanova*** (azem@math.lsu.edu), Baton Rouge, LA 70820. *Reconstructing free surfaces for a flow of ideal fluid around supercavitating wedges.*

The problem of one or two supercavitating wedges in the jet of the ideal fluid is solved in the closed form. Tulin-Terent'ev single-spiral-vortex model is assumed for the closure of the cavities. Using conformal map from the parametric complex plane onto the flow domain the problem is reduced to two Riemann-Hilbert boundary value problems on the hyperelliptic Riemann surface. The nonlinear system for the accessory parameters of the conformal map is solved numerically. The shape of the cavity and the free boundary is reconstructed for a supercavitating wedge under free surface. (Received August 21, 2008)

1046-76-322 **Elizabeth Thoren*** (ethoren@math.utexas.edu), Department of Mathematics, 1 University Station C1200, Austin, TX 78712-0257. *Linear instability criteria for Euler's equation: two classes of perturbations.* Preliminary report.

One criteria for linear instability of a steady flow of an ideal incompressible fluid involves computing the essential spectral radius of the associated evolution operator for the linear perturbation about the steady equilibrium. This quantity is known to be equal to a Lyapunov type exponent associated with the equilibrium flow. In this work, the essential spectral radius of the linear evolution operator is investigated in the invariant subspace corresponding to the perturbations preserving the topology of the vortex lines and the associated factor space. (Received August 26, 2008)

1046-76-748 **David M Holland*** (holland@cims.nyu.edu), 251 Mercer St., Rm 929, New York, NY 10012. *Observations and Modeling of Ice Sheet - Ocean Interaction.* Preliminary report.

In this talk we review some of the recent advances in observations and modeling of ice sheet and ocean interaction. In particular, we will focus on the ice shelves that frigne large areas of the coastlines of Antarctica and Greenland. Such ice shelves are relevant because they are believed to act as a 'backstop' that keeps the inland ice from quickly entering into the ocean, and thus driving up global sea level. There remains considerable uncertainty in both the understanding of the key physical processes governing ice shelf behavior and the optimal numerical scehemes to represent such relatively small scale features with the context of global cliamte simulations. Predicting the behavior of the ice shelves in a changing climate, and hence of global sea level, is a major goal for coupled models of the climate system. (Received September 10, 2008)

1046-76-1216 **James Glimm*** (glimm@ams.sunsyb.edu), Dept. of Applied Math & Statistics, Math Tower, Room P-138A, Stony Brook University, Stony Brook, NY 11789. *Scientific Computing At Stony Brook University.*

The Stony Brook Applied Mathematics Department, and the New York Center for Computational Science (NYCCS) offer research programs in awide variety of computational science research areas. This talk will serve to introduce a few of these, including models of spray andbreakup of a jet of diesel fuel in a diesel engine, models of fueling ofthe ITER magnetically confined fusion reactor, design of a scram jet, and design of methods to impede flow of contaminants in ground water. (Received September 15, 2008)

1046-76-1402 **Aleksandar Donev*** (donev1@llnl.gov), P.O.Box 808, L-367, Livermore, CA 94551-9900, and **Alejandro L Garcia** and **Berni J Alder**. *A hybrid particle-continuum (DSMC-SPDE) algorithm for dense fluid flows.*

We present a hybrid method that couples an explicit fluctuating compressible Navier-Stokes solver with a mesoscopic particle method that generalizes the Direct Simulation Monte Carlo (DSMC) method to dense fluids [A. Donev and A. L. Garcia and B. J. Alder, Phys. Rev. Lett. 101:075902, 2008]. The coupling is flux-based and generalizes previous work [J. B. Bell and A. Garcia and S. A. Williams, SIAM Multiscale Modeling and Simulation, 6:1256-1280, 2008] to dense fluids. The method is applied to the modeling of complex fluids such as colloidal and polymer suspensions.

Note: This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344 (LLNL-ABS-406945). (Received September 15, 2008)

1046-76-1581 **Kara L. Maki*** (maki@math.udel.edu), 324 Ewing Hall, Department of Mathematical Sciences, University of Delaware, Newark, DE 19716, and **Richard J. Braun**, **William D. Henshaw** and **P. Ewen King-Smith**. *Human tear film dynamics with an overset grid method.*

We present recent progress in the understanding of the dynamics of the human tear film on the complex eye-shaped geometry. The evolution is modeled during relaxation (after a blink) using lubrication theory and the effects of viscosity, surface tension and gravity are explored. The highly nonlinear governing partial differential equation is solved on an overset grid by a method of lines coupled with finite differences. Our two-dimensional simulations, calculated in the Overture framework, recover features seen in one-dimensional simulations and mimic some experimental observations like hydraulic connectivity around the lid margins. (Received September 16, 2008)

1046-76-1597 **Roberto Camassa** and **Joyce T. Lin*** (jtlin@email.unc.edu), Department of Mathematics, University of North Carolina at Chapel Hill, CB# 3250, Phillips Hall, Chapel Hill, NC 27599, and **Richard M. McLaughlin**. *Falling Spheres in Stratified Fluids.*

Low settling rates are observed for small particulate matter in strongly, stably stratified fluid. As the particle passes through an interface between two layers of fluid, it entrains lighter, upper fluid. The significance of this entrained fluid in the low Reynolds regime, along with a model for the behavior of the particle, has not yet been fully explored. We present careful measurements performed in stratified corn syrup showing the effects of the enhanced drag due to entrained fluid on the sphere at low Reynolds. We develop a model from first principles on the hydrodynamics, which involves a strong coupling between the variable density fluid and moving solid boundary. (Received September 16, 2008)

1046-76-1687 **Esteban G. Tabak*** (tabak@cims.nyu.edu), Esteban G. Tabak, New York University, 251 Mercer Street, New York, NY 10012, and **Helga S. Huntley**. *An optmization approach to modeling sea-ice dynamics.*

A new model for the dynamics of sea ice is proposed, where the pressure field is computed, not from a local rheology, but from a global optimization problem. The pressure emerges as a Lagrange multiplier that enforces the ice resistance to compression while allowing divergence. The resulting variational problem is solved by minimizing the pressure globally throughout the domain, constrained by the equations of momentum and mass conservation, as well as the limits on ice concentration (which has to stay between 0 and 1). This formulation has an attractive mathematical elegance while being physically motivated. Moreover, it leads to an analytic formulation that is also easily implemented in a numerical code, which exhibits marked stability and is suited to capturing discontinuities.

A finite ice strength is incorporated into the model as a second optimization step, minimizing the change in ice thickness necessary to satisfy the upper bound on the pressure, whereby ice strength is taken to be a function of thickness. (Received September 16, 2008)

1046-76-1789 **Russel E Caflisch*** (rcaflisch@ipam.ucla.edu), 460 Portola Plaza, Los Angeles, CA 90095-7121. *Accelerated Computational Methods for Fluid and Plasma Dynamics.*

We present accelerated simulation methods for rarefied gas dynamics (RGD) and Coulomb collisions in a plasma. We describe a hybrid method that combines a Monte Carlo particle simulation and a fluid dynamic solver in a single uniform method throughout phase space. The hybrid method is based on a representation of the velocity distribution function $f(v)$, as a combination of a Maxwellian equilibrium $M(v)$ and a collection of discrete particles $g(v)$. The Maxwellian M evolves in space and time through fluid-like equations, and the particles in g convect and collide through a standard Monte Carlo particle method, such as DSMC for RGD or Nanbu's method for Coulomb collisions. Interactions between M and g are represented by a thermalization process that removes particles from g and includes them in M and a dethermalization process that samples particles from M and inserts them into g. We also discuss renormalization group procedures to describe fluctuations in plasmas. (Received September 17, 2008)

1046-76-1824 **Joanna A Bieri*** (joanna@u.northwestern.edu), 909 Elmwood Ave #H2, Evanston, IL 60202. *Dynamics of Edge-Flames in Micro-Channels.* Preliminary report.

The dynamics of an edge-flame in a narrow channel is studied within the context of a thermal-diffusive model. Fuel and oxidizer, separated upstream by a thin plate of finite length, flow through a channel with a prescribed velocity. At the end of the plate they mix and, when ignited, an edge-flame is sustained at some distance from the plate. Typically, the flame, which is stabilized by heat conduction back to the cold plate, has a tribrachial structure. It consists of a leading edge made up of lean and rich premixed segments and a diffusion flame trailing behind. The objective of this work is to determine the effect that the channel walls have on the edge standoff distance, on the flame shape and on the flame stability. In particular, we examine the influence of channel width and mixture strength and the effects of differential diffusion. Both the steady and unsteady governing equations are solved numerically using a finite difference second-order approximation in space and an explicit marching procedure in time. We examine boundary conditions ranging from adiabatic to cold isothermal walls.

We determine conditions under which the edge-flame is stabilized near the tip of the splitter plate, is held near the tip but oscillates back and forth, or is blown-off. (Received September 16, 2008)

1046-76-1964 **Roxana Tiron*** (tiron@email.unc.edu), 118 Bim Street, Apt G, Carrboro, NC 27510, and **Roberto Camassa**, **Ann Almgren** and **Amber Sallerson**. *Unstable internal waves.*

Internal waves propagating in a stratified ocean have been observed and reported to have large amplitudes. Understanding the breaking mechanisms of these waves is crucial for explaining mixing and transport phenomena within the ocean. As experimental observations show, for near two layer stratification, waves become unstable in large am plitude regimes and the wave-breaking closely resembles Kelvin Helmholtz shear instability originating in the maximum displacement of the pycnocline region. The instability is modulated by the stream-wise variation of the shear. We simulate numerically the generation and propagation of solitary waves starting from a step function initial con dition and monitor the wave-induced shear instabilities. A conservative pro jection method for the variable density Euler equations is implemented in this scope. The code is validated against experimental data as well as theoretical results. In an effort to elucidate wether the instabilities are an intrinsic property of the wave or they are induced by the experimental generation, we study the time evolution of traveling wave solutions. (Received September 16, 2008)

78 ► Optics, electromagnetic theory

1046-78-260 **Lyubima Boteva Simeonova*** (simeonov@math.utah.edu), 155 So. 1400 E., Department of Mathematics, Salt Lake City, UT 84102, and **David C Dobson** (dobson@math.utah.edu), 155 So 1400 E, Department of Mathematics, Salt Lake City, UT 84102. *Spatial Bounds on the Effective Complex Permittivity for Time-Harmonic Waves in Random Media.*

The effective complex permittivity for time-harmonic waves in random media is investigated. Wave localization and cancellation must be accounted for when the wavelength is in the same order as the size of the heterogeneities, which means that the effective coefficients are no longer constants as in the quasistatic case, but functions of the space variable. The definition of the effective dielectric coefficient provided comes naturally from the equations. It does not prevent spatial variations and is consistent with the definition of the effective dielectric constant in the quasistatic regime. Numerical results that emphasize the presence of spatial variations in the effective dielectric coefficients as the frequency increases from 0 (which will decrease the wavelength) are presented. These are due to the scattering effects. In two- and three- dimensional media, the spatial variations of the effective dielectric coefficient are bounded in terms of the size of the inhomogeneities, the contrast in the medium, and the frequency. It also shown that as the size of the inhomogeneities goes to zero, the effective coefficient approaches the constant consistent with the one in the quasistatic regime. (Received August 24, 2008)

1046-78-295 **Anjan Biswas*** (biswas.anjan@gmail.com), Department of Applied Mathematics and Theoret, 1200 N DuPont Hwy, Dover, DE 19901-2277. *Optical solitons with time-dependent dispersion, nonlinearity and attenuation.*

Optical solitons with time-dependent coefficients of dispersion, nonlinearity and attenuation is studied in a non-Kerr law media. The 1-soliton solution is obtained for the nonlinear Schrödinger's equation. In addition, a relation between these coefficients is obtained for the solitons to exist. Finally, the velocity of the soliton is also obtained in terms of these time-dependent coefficients (Received August 25, 2008)

1046-78-300 **Patrice Green*** (pgreen@desu.edu), Dept of Applied Math and Theoretical Physics, 1200 N Dupont Hwy, Dover, DE 19901, **Dawn Lott** (dlott@desu.edu), Department of Mathematics, 1200 N Dupont Hwy, Dover, DE 19901, and **Anjan Biswas** (biswas.anjan@gmail.com), Dept of Applied Math & Theoretical Physics, 1200 N Dupont Hwy, Dover, DE 19901. *Dynamics of super-Gaussian Optical Solitons by Collective Variables Method.*

This work studies the classical optical solitons in presence of perturbation terms that arises in various contexts of the propagation of solitons through optical fibers. The adiabatic parameter dynamics of these solitons are laid down by the aid of collective variables method. super-Gaussian solitons are considered. Finally, the numerical simulations are obtained to complete the study. (Received August 25, 2008)

1046-78-318 **Dawn Alisha Lott*** (dlott@desu.edu), Applied Mathematics and Theoretical Physics, Delaware State University, 1200 N. DuPont Highway, Dover, DE 19901, and **Anjan Biswas** (abiswas@desu.edu), Applied Mathematics and Theoretical Physics, Delaware State University, 1200 N. DuPont Highway, Dover, DE 19901. *A numerical study of optical soliton-like structures resulting from the nonlinear Schrödinger equation with square-root law nonlinearity.*

An analytical and numerical investigation of the propagation of optical beams in Kerr term-like saturable photorefractive media is performed. The major problem studied is the instability of beam propagation in nonlinear self-focusing optical media by the Runge-Kutta finite-difference numerical technique. The resulting soliton-like structures propagate and develop modulational instabilities which lead to the breakup of simple beam arrangements into more complex ones. The direct numerical simulation of the nonlinear Schrödinger's equation with square root law nonlinearity is performed. Gaussian, super-Gaussian, and sech pulses pulses are obtained numerically. Finally the ordinary differential equation that is obtained by the travelling wave ansatz is also studied numerically, with appropiate initial condition, leading to a traveling wave-like solution. (Received August 26, 2008)

1046-78-852 **Natalie A. Cartwright*** (cartwrin@newpaltz.edu), Department of Mathematics, SUNY New Paltz, New Paltz, NY 12561, and **Kurt E. Oughstun** (oughstun@cems.uvm.edu). *Pulse Propagation in a Debye Material with Static Conductivity: The Search for a Uniform Expansion.* Preliminary report.

We study the propagation of an ultrawideband electromagnetic pulse through a semiconductor with complex dielectric permittivity given by a Debye model with static conductivity σ, as

$$\epsilon_c(\omega) = \epsilon_\infty + \frac{\Delta\epsilon}{1 - i\omega\tau} + i\frac{\sigma}{\omega}.$$

Our method of analysis is an asymptotic approximation to the integral representation of the electric field component of the propagated field

$$E(z,t) = \frac{1}{2\pi}\int_{ia-\infty}^{ia+\infty} \tilde{E}(0,\omega)\exp\left[\frac{z}{c}\phi(\omega,\theta)\right] d\omega,$$

where $z > 0$ is the propagation distance into the material. Here, $a > 0$ is a constant, $\tilde{E}(0,\omega)$ is the temporal spectrum of the pulse in the plane $z = 0$, $\phi(\omega,\theta) = i\omega\left[\epsilon_c^{1/2}(\omega) - \theta\right]$ is the complex phase function, $\theta = ct/z$ is a space-time parameter and c denotes the speed of light in vacuum.

We have found non-uniform asymptotic expansions that provide a valid approximation to the propagated field for low and high levels of static conductivity. In this talk, we will address the issues faced in finding a uniform description that is valid for all levels of static conductivity. (Received September 12, 2008)

1046-78-1154 **weiwei zhang*** (weiweizhang@kings.edu), 133, north river st., wilkes-barre, PA 18711. *Calculation of the EM Fields for scattering from Large Cavities.*

Open cavity recessed in an infinite ground plan can serve as a model of duct structures such as jet engine intakes of an aircraft or antenna windows embedded in complicated structures. The phenomena are governed by the Helmholtz equation in an infinite domain along with the radiation condition and Perfect Electric Conductor boundary conditions. The prediction and reduction of Radar Cross Section (or echo area) of this structure are very important and require the information of the fields in a board range of frequencies. In this talk, the asymptotic technique is applied finding the solution of the problem and an efficient algorithm is designed base on it. (Received September 14, 2008)

1046-78-1704 **Deborah A Koslover*** (dkoslover@uttyler.edu), University of Texas at Tyler, Department of Mathematics, RBN 4010, 3900 University Blvd, Tyler, TX 75701, and **Ron Pieper** (rpieper@uttyler.edu). *Four-order acousto-optic diffraction for Bragg incident light.*

Acousto-optics, the study of the interaction of sound and light waves, provides tools for the control of laser light. Sound waves propagated through columns of material change the index of refraction of the material. Laser light directed through the material is then diffracted allowing for both deflection and modulation of the beam. Proper choice of incident angle for the input laser light, the Bragg angle, results in 90% of the incident power diverted into the first diffracted order. Both analytic and computational methods are used to study the system of differential equations which describe this diffraction for arbitrary boundary conditions. (Received September 16, 2008)

80 ► Classical thermodynamics, heat transfer

1046-80-1529 **Katsuyo Thornton*** (kthorn@umich.edu), 2300 Hayward St., Ann Arbor, MI 48109.
Simulation of Microstructures in Energy Conversion Systems.

The properties and performance of a wide range of materials depend on their microstructures. This is especially true in energy conversion systems, in which different phases perform different functions. Therefore, controlling microstructures is one of the main routes in designing such multifunctional materials for optimal performance. Through coupling of simulations of microstructural evolution and transport that use realistic microstructures, microstructural design for optimized performance is investigated. Simulation methods such as the phase-field modeling and transport simulation will be discussed. Specific applications are demonstrated for solid oxide fuel cell electrodes and self-assembled bicontinuous two-phase microstructures. (Received September 15, 2008)

1046-80-1866 **Matthew Glomski*** (Matthew.Glomski@marist.edu), Poughkeepsie, NY 12601. *Existence and uniqueness of the critical wave number for the asymmetric planar Bénard problem.* Preliminary report.

Rayleigh-Bénard convection is a much researched thermodynamical phenomenon, yet significant unanswered questions remain. In this talk, we will present an outline of a proof of the existence and uniqueness of the critical wave number for the linearized planar Bénard problem on the hexagonal lattice. The proof relies on both analytical techniques first developed by Hassard and Jeng, as well as on more traditional methods in classical fluid dynamics. (Received September 16, 2008)

81 ► Quantum theory

1046-81-8 **Mikhail Khovanov*** (khovanov@math.columbia.edu), Department of Mathematics, Columbia University, New York, NY 10027. *Categorification of quantum groups and link invariants.*

We will outline new structural developments on the intersection of low-dimensional topology, representation theory and homological algebra that lead to categorification of various link invariants and categorification of quantum groups. (Received September 17, 2008)

1046-81-255 **John R. Klauder*** (john.klauder@gmail.com), Department of Mathematics, University of Florida, P O Box 118105, Gainesville, FL 32611-8105. *Nonrenormalizability Tamed!*

Within a Euclidean-spacetime, lattice-regularized functional integral, a novel and nonclassical counter term acts to eliminate term-by-term divergences in a perturbation analysis of the mass term as well as that of a general nonlinear interaction. The continuum limit of the regularized functional integral expression promises to define a relativistically covariant quantum field theory. (Received August 23, 2008)

1046-81-270 **Susama Agarwala*** (agarwala@math.jhu.edu). *Differential Geometry on a Renormalization Bundle.*

Connes and Marcolli, arXiv:hep-th/0411114, capture the problem of renormalizing a scalar quantum field theory in terms of a connection on a complex bundle. I present an overview of that bundle, and apply it to a scalar quantum field theory for curved space-time, using ζ function regularization. This gives the result that the contributions of each Feynman graph to the β function is dependent only on the curvature of the background manifold. (Received August 25, 2008)

1046-81-556 **Christopher Scott Hiatt*** (hiatt_c@utpb.edu), 2910 W Michigan Ave #204, Midland, TX 79701. *Quantum Traces In Quantum Teichmüller Theory.* Preliminary report.

We prove that for the torus with one hole and $p \geq 1$ punctures and the sphere with four holes there is a family of quantum trace functions in the quantum Teichmüller space satisfying the properties proposed by Chekhov and Fock in *Observables in 3D Gravity and Geodesic Algebras*, from: "Quantum groups and integrable systems (Prague, 2000)", Czechoslovak J. Phys. 50 (2000) 1201-1208 MR1806262. (Received September 08, 2008)

1046-81-615 **Daniel Krasner*** (dkraner@math.columbia.edu), 542 W 112th st #5H, New York, NY 10025. *Equivariant sl(n)-link homology.*

For every positive integer n, M. Khovanov and L. Rozansky constructed a bigraded link homology theory with Euler characteristic the quantum sl(n)-link polynomial. Matrix factorizations played an integral part in their construction. I will discuss these theories and a generalization that is motivated by the "universal" rank two Frobenius extension studied by M. Khovanov for sl(2)-homology. This equivariant sl(n)-link homology should be a starting point of unraveling some inherent structural properties of the Khovanov-Rozasnky link homology and related theories. (Received September 09, 2008)

1046-81-736 **Nicholas Read*** (nicholas.read@yale.edu). *Quantum Hall wavefunctions and topological quantum field theories.*

This talk will review the use of conformal blocks from a rational conformal field theory as so-called "trial wavefunctions" for the fractional quantum Hall effect. These functions are essentially symmetric polynomials in N complex variables. The physical idea of adiabatic transport as N goes to infinity sets up a projectively-flat connection on a moduli space of these functions, whose properties can be characterized when some hypotheses are satisfied. This leads to a theoretical physics construction of many topological quantum field theories. These are connected with invariants of three-manifolds and of links. Recent work with Zhenghan Wang connects the case of antisymmetric wavefunctions for fermions with invariants of three-manifolds with a spin structure and with "spin modular categories". (Received September 10, 2008)

1046-81-808 **Stephanie A. Blanda*** (sab002@lvc.edu), 1793 Ashton Drive, Lebanon, PA 17046. *Multiparty Quantum States with Nearly Maximal Stabilizer.*

A goal of quantum information is the development of quantum computers, which would perform certain computational tasks exponentially faster than classical computers. In analogy with classical computers, which have the bit as their basic unit of information, the quantum bit (qubit) is the basic unit of information in quantum computing. Unlike classical bits, a qubit state can be a mixture (or superposition) of 0 and 1. Our research studies the n-qubit phenomenon called entanglement – an important but poorly understood resource for quantum information processing and communication. Entanglement properties are shared by states that are equivalent under the action of the local unitary (LU) group. We get a partial classification of entanglement by classifying stabilizer subgroups of the LU group. My work presented in this talk solves the problem of what n-qubit states (for $n > 2$) have stabilizers with one less than the maximum possible dimension. (Received September 11, 2008)

1046-81-931 **Gregory W. Moore*** (gmoore@physics.rutgers.edu). *Self-duality and generalized differential cohomology.*

The familiar relation of edge-state chiral bosons to Chern-Simons theories in three dimensions is generalized to the theory of self-dual fields quantized by a Pontryagin self-dual cohomology theory. We emphasize examples of some importance in string theory including the self-dual 3-form in six dimensions and the RR field of type II string theory. We apply this theory to the theory of RR fields in orientifolds of type II string theory. This will be based on work done over the past few years with D. Belov, J. Distler, D. Freed, and G. Segal. (Received September 12, 2008)

1046-81-1509 **Israel Klich*** (ik3j@Virginia.EDU). *Quantum Noise and the Entanglement Entropy of Fermions.*

Entanglement entropy is a measure of quantum many body correlations between the parts of a many body system. It has emerged as a useful quantity in broad areas of theoretical physics, from cosmology to condensed matter and quantum information. In this talk I will discuss the problem of entanglement entropy of fermions and it's relation to Widom's conjecture. I will also describe a universal relation between entanglement entropy and statistics of current flowing through a quantum point contact. This relation provides a way to experimentally measure entanglement entropy, and test seminal results of conformal field theory such as the prediction of Holzhey, Larsen and Wilczek for entanglement entropy of fermions. (Received September 15, 2008)

1046-81-1724 **Kevin C. Murphy*** (kcmurphy@math.uiowa.edu), 2890 Coral Court Apt. 201, Coralville, IA 52241. *Vacuum and Bound State Calculations in Point Form Quantum Field Theory.*

One of the ways of generating a Poincare covariant quantum field theory is to construct four-momentum and Lorentz generators that satisfy the commutation relations of the Poincare algebra. I show how to do this when the four-momentum operators carry interactions, and the Lorentz generators do not. Since the four-momentum operators commute among themselves, they can be used to generate vacuum and bound states as generalized eigenvectors. I will discuss the structure of Lorentz invariant equations whose solutions give the generalized eigenvectors. (Received September 16, 2008)

1046-81-1735 **Itzhak Bars*** (bars@usc.edu), Department of Physics and Astronomy, University of Southern California, Los Angeles, CA 90089-0484. *Twistors and 2T-physics as unifiers of 1T-physics systems.*

2T-physics in 4+2 dimensions is used as a tool to construct a generalized twistor transform for spinning particles in 3+1 dimensions that unifies many types of particle dynamics. The particle systems described by the same twistor include not only freely moving massless relativistic particles in flat 3+1 space-time, but also massive relativistic or non-relativistic particles, non-interacting or interacting in special ways, and moving in special curved space-times. A common feature of the unified systems is that they all have a hidden global SU(2,3) symmetry and they all are in the same fixed infinite dimensional unitary representation of this symmetry. Furthermore, their classical and quantum dynamics are all captured by the same SU(2,2) twistor. This SU(2,2)=SO(4,2) is the familiar conformal symmetry for the case of massless particles, but is a hidden unfamiliar symmetry of the other systems. Because of the underlying hidden twistor and SU(2,3) properties there exists remarkable duality relationships among these systems. (Received September 16, 2008)

1046-81-1870 **Hillel M Raz***, hraz@math.ucdavis.edu. *Lieb-Robinson bound on the anharmonic lattice.*
We prove a Lieb-Robinson type bounds for systems defined on infinite dimensional Hilbert spaces and described by unbounded Hamiltonians. In particular, we prove the existence of such a bound for certain anharmonic lattice systems. (Received September 16, 2008)

83 ► Relativity and gravitational theory

1046-83-261 **Jennie D'Ambroise*** (jdambroise@hotmail.com), Dept of Mathematics and Statistics, Lederle Graduate Research Tower, Umass Campus, Amherst, MA 01003. *An uncoupled EMP formulation of a Bianchi I scalar field cosmology.*
Various authors such as J. Lidsey, T. Christodoulakis, T. Grammenos, C. Helias, P. Kevrekidis, G. Papadopoulos and F. Williams are known to have formulated equivalent versions of the 3+1-dimensional Einstein's field equations in terms of a so-called generalized Ermakov-Milne-Pinney (EMP) differential equation. This reformulation provides an alternate method for acquiring exact solutions to the field equations, and has been accomplished within the frameworks of FRLW and some Bianchi universe models. In the case of the particular conformally Bianchi I model in question here, the EMP has been shown by F. Williams to be coupled to a second equation. The author will present an uncoupled version of this cosmological model, as well as its relation to a linear Schrodinger equation. (Received August 24, 2008)

1046-83-1151 **George Sparling*** (gnilraps@gmail.com). *New ideas in space-time: Cartan's ODE's, parabolic geometry and conformal structures.*
I will describe recent work of Boris Doubrov, Jonathan Holland and myself, showing how Cartan's classic work on the equivalence problem for ordinary differential equations may be applied to the study of space-time. The overall aim here is to gain new insight into the structure of the Einstein vacuum equations, generalizing the twistor theory of Penrose to the non-self-dual case. (Received September 14, 2008)

1046-83-1156 **Eric Korman***, Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15213. *Fierz identities for real Clifford algebras.*
I will discuss the invariant structure of real Clifford algebras associated to metrics of arbitrary signature. I will systematically describe the Fierz identities obeyed by the spinor representations of these algebras. These identities will be linked to the spinor projection formulas of Penrose. (Received September 14, 2008)

1046-83-1727 **Niky Kamran***, Department of Mathematics and Statistics, McGill University, 805 Sherbrooke Street West, Montreal, Quebec H3A 2K6, Canada. *The Penrose process and the wave equation in Kerr geometry.*
We shall review the Penrose process for extracting mass and angular momentum from the Kerr black hole solution of the Einstein equations. We will show that Christodoulou's bound on the maximal energy gain by the classical Penrose process can be realized by choosing suitable wave packet initial data for the scalar wave equation in Kerr geometry, thereby putting super-radiance on a rigorous mathematical footing. This is joint work with Felix Finster, Joel Smoller and Shing-Tung Yau. (Received September 16, 2008)

1046-83-1833 **Deborah A. Konkowski*** (dak@usna.edu), Department of Mathematics, U.S. Naval Academy, Annapolis, MD 21402, and **Thomas M. Helliwell** (helliwell@HMC.edu), Department of Physics, Harvey Mudd College, CLaremont, CA 91711. *Quantum Non-Singularity of Spacetimes with Higher Order Diverging Differential Curvature Invariants.*
The classical singularity structure of general relativistic spacetimes is determined by incomplete geodesics and the divergence of scalar polynomials in the curvature. The quantum singularity structure is determined by the essential self-adjointness of scalar wave operators evaluated for test fields in the spacetimes. Here we show that

spacetimes with higher order divergence in the scalar polynomials are quantum mechanically non-singular and we discuss the possible implications for the cosmic censorship hypothesis. (Received September 16, 2008)

85 ► Astronomy and astrophysics

1046-85-1012 **Christopher J Winfield*** (winfielc@uwosh.edu), Mathematics Dept., 800 Algoma Boulevard, Oshkosh, WI 54901. *Type Ia Supernova Luminosity Data and the LTB Model: A Well-posedness Problem.* Preliminary report.

Solutions to the Einstein equation given by the spherically symmetric Lemaître-Tolman-Bondi metric (on $\mathbb{R}^4$) are studied where data is prescribed in terms of a so-called redshift parameter $z \geq 0$. As such solutions are characterized by functions $E(r)$, $M(r)$, and $R(t,r)$ satisfying

$$\left(\frac{\partial_t R}{R}\right)^2 = \frac{2E}{R^2} + \frac{2M}{R^3},$$

we study maps of the form $\{E(r(z)), D_L(z), R(0, r(z))\} \to M(r(z))$ for observable $D_L(z)$ [Chung, Romano: arXiv:astro-ph/0608403v1]. Here D_L is incorporated into the solution by $D_L(z) = (1+z)^2 R(t(z), r(z))$ where $(t(z), r(z))$ lie on certain null (photon) geodesics (i.e. $ds^2 = 0$). We investigate the well-posedness of the resulting system of ordinary differential equations

$$\frac{dr}{dz} = \frac{\sqrt{1+2E(r(z))}}{(1+z)\partial_t\partial_r R(t(r), r(z))}$$
$$\frac{dt}{dz} = \frac{|\partial_r R(t(z), r(z))|}{(1+z)\partial_t\partial_r R(t(r), r(z))}.$$

We further discuss possible directions and how our investigation pertains to cosmological models such as dark-energy, inhomogeneous matter distribution, and the cosmological constant. (Received September 16, 2008)

1046-85-1188 **Tiancheng Ouyang** (ouyang@math.byu.edu), 292TMCB, Brigham Young University, Provo, UT 84602, and **Duokui Yan*** (duokuiyan@gmail.com), 292TMCB, Brigham Young University, provo, UT 84602. *collinear four-body problem.*

The regularization of the collinear SBC is showed by using a different method. Also, we show the existence of two constants in the solution which have special meanings. Secondly, we discover a schubart-like periodic orbit for non-symmetric masses with [m1 m2 m3 m4]=[1 1 1 m]. The analytic proof for the existence of such periodic orbits are given and numerical evidence is also provided. (Received September 15, 2008)

1046-85-1795 **Ann S Almgren*** (asalmgren@lbl.gov), MS 50A-1148, 1 Cyclotron Rd, LBNL, Berkeley, CA 94549, and **John B Bell**, **Andy J Nonaka** and **Mike Zingale**. *Low Mach Number Modeling of Type Ia Supernovae.* Preliminary report.

Low Mach number methods provide an accurate and efficient way to numerically simulate low-speed flows in which acoustic wave propagation is not physically significant. In low Mach number methods one assumes a background state relative to which the variation in pressure must be small. Successful applications of these types of methods include low-speed combustion with a constant pressure background state, flows in the Earth's atmosphere with a hydrostatically stratified but constant-in-time background state, and a limited class of astrophysical flows for which the variations in temperature are small and the background state unchanging. Recently we have extended the low Mach number approach to a much more general class of astrophysical flows, now allowing large variations of temperature relative to the base state, and allowing the background state to evolve in time. In this talk I will describe how to derive the correct low Mach number equations for the convective phase of a Type Ia supernova, and will show a brief movie of our results so far. (Received September 16, 2008)

1046-85-1818 **Skyler C. Simmons*** (xinkaisen@yahoo.com), 292 TMCB, Brigham Young University, Provo, UT 84602, and **Duokui Yan** and **Tiancheng Ouyang**. *A new family of periodic orbits with singularities in the 2D n-body problem.*

Singularities of the n-body problem in celestial mechanics have been studied for many years. Important results include the transformations given by Sudman, Siegel and Moser for binary collision and McGehee for triple collison. More recently, Yan has studied the simultaneous binary collision problem in one dimension. Here, we consider orbits of even numbers of bodies in the n-body problem. A method for constructing periodic orbits of n bodies is given. A key feature of these orbits is multiple simultaneous binary collision. (Received September 16, 2008)

86 ► Geophysics

1046-86-122 **Kenneth M. Golden***, University of Utah, Department of Mathematics, Salt Lake City, UT. *Mathematics of sea ice to help predict climate change.*

Sea ice is both an indicator and agent of climate change. It also serves as a primary habitat for microbial communities sustaining life in the polar oceans. Fluid flow through porous sea ice mediates a broad range of processes, such as the growth and decay of seasonal ice, the evolution of summer ice albedo, and biomass build-up. A new understanding of the fluid permeability of sea ice, and the thermal evolution of its microstructure, promises to improve forecasts of how global warming will affect earth's icepacks, and how polar ecosystems may respond. Related work on electrical properties will help in monitoring ice thickness. Video from a 2007 Antarctic expedition where we measured fluid and electrical transport in sea ice will be shown. (Received July 29, 2008)

1046-86-144 **Mayer Humi*** (mhumi@wpi.edu), Math Dept,WPI, 100 Institute Rd, Worcester, MA 01609-2247. *Long's Equation in Terrain Following Coordinates.*

Long's equation describes two dimensional stratified atmospheric flow over terrain which is represented by the geometry of the domain. The solutions of this equation over simple topography were investigated analytically and numerically by many authors. In this paper we derive a new terrain following formulation of this equation which incorporates the terrain as part of the differential equation rather than the geometry of the domain. This leads to new analytic insights about the solutions of this equation and enable us to compute steady state gravity wave patterns over complex topography. (Received August 06, 2008)

1046-86-382 **Bogdan G. Nita*** (nitab@mail.montclair.edu), 1 Normal Avenue, Montclair, NJ 07043. *An algorithm for seismic imaging and amplitude correction derived from scattering theory.*

We present a method, derived from inverse scattering theory, for geophysical imaging and amplitude correction from measured data. No knowledge about the medium under investigation is assumed. Although derived from, and as a series, the algorithm is shown to converge to a closed form independent of the parameters involved in the problem. An analytic one dimensional example shows excellent results in finding both the location of interfaces and the amplitude of acoustic reflections. (Received August 29, 2008)

1046-86-900 **Deborah Sulsky*** (sulsky@math.unm.edu), Department of Mathematics and Statistics, Albuquerque, NM 87131, and **Kara Peterson**, **Giang Nguyen** and **Howard Schreyer**. *Modeling Sea-Ice Mechanics.*

Sea ice regulates heat, moisture and salinity in the polar oceans. In the winter, sea-ice insulates relatively warm ocean water from colder air, except where cracks, or leads, allow heat and water vapor to escape from the ocean to the atmosphere. This exchange affects cloud cover and precipitation. Freezing of water exposed in leads also causes brine to be ejected into the ocean. These factors impact worldwide ocean currents, weather patterns and ecosystems.

Motion of the ice pack is driven by the atmosphere and ocean. The ice pack is able to move and deform because of concentrated deformation at leads. An elastic-decohesive constitutive model for pack ice has been developed that explictly accounts for leads. The constitutive model is based on elasticity combined with a cohesive crack law that predicts the initiation, orientation and opening of leads, and also has a simple closing model. Example calculations using the Material-Point Method and the elastic-decohesive constitutive model are performed for rectangular regions of Arctic ice near a coastline. Simulations will also be presented for an area of the Beaufort Sea, where predictions can be validated against satellite observations of the Arctic. (Received September 12, 2008)

1046-86-1056 **Donald K Perovich*** (donald.k.perovich@usace.army.mil), ERDC-CRREL, 72 Lyme Road, Hanover, NH 03755. *Sunlight, water, and ice: The sea ice-albedo feedback in a changing climate.*

Climate change is a complex and crucial environmental issue. General circulation models indicate that the Arctic is a region where a warming signal will be the strongest. The sea ice cover of the Arctic Ocean is a grand integrator of heat and thus plays a key role as an indicator of climate change. Over the past few decades the Arctic sea ice cover has decreased both in areal extent and in thickness. These changes have altered the partitioning of solar radiation in the Arctic atmosphere-ice-ocean system. Calculations indicate an increase in the solar energy deposited in the upper ocean over the past few decades. The largest increases in total annual solar heat input, as much as 4% per year, occurred in the Chukchi Sea region. In the summer of 2007, there was an extraordinarily large amount of ice bottom melting observed in the Beaufort Sea region. An increase in the open water fraction resulted in a 500% positive anomaly in solar heat input to the upper ocean. The melting in the Beaufort Sea has elements of a classic ice albedo feedback signature: more open water leads to more solar heat absorbed, resulting in more melting and more open water. The ice albedo feedback can serve as an amplifier of climate change accelerating the ongoing reduction in Arctic sea ice. (Received September 14, 2008)

1046-86-1185 **Willi Freeden*** (freeden@mathematik.uni-kl.de), TU Kaiserslautern, Geomathematics Group, 67663 Kaiserslautern, Germany. *Inverse Potential Theory on the Sphere.*

The talk deals with inverse potential theory on the sphere and its applications to problems in (terrestrial) Earth's gravity determination and (geostrophic) ocean circulation modeling. (Received September 15, 2008)

1046-86-1242 **Elizabeth C. Hunke*** (eclare@lanl.gov), MS-B216, Los Alamos National Laboratory, Los Alamos, NM 87545. *Sea Ice Modeling in the GCM Context.*

Global Climate Models (GCMs) must balance limitations in computing resources and manpower with the need to simulate all aspects of the climate system accurately and in detail. As a result, polar simulations of GCMs often receive less attention than do the lower latitudes. This presentation will provide a global climate modeling perspective on the polar regions from the point of view of a GCM/sea-ice modeler, including an overview of the sea ice components in current IPCC-class GCMs. One of these models features some striking advances in its simulation of the polar regions since the recent IPCC modeling cycle; I will discuss the current status of this model and our plans for further improving the cryospheric component of GCMs. (Received September 15, 2008)

1046-86-1424 **Ron Kwok*** (ron.kwok@jpl.nasa.gov), 300-235, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109. *Sea ice thickness and kinematics.*

Large-scale circulation of sea ice determines the advective part of the ice balance and provides a velocity boundary condition on the ocean surface. Small-scale ice motion controls the abundance of thin ice and the many surface processes dependent on thin ice, such as turbulent heat flux to the atmosphere. Smaller scale processes in the ice cover involve the detailed motion of individual floes, aggregate of floes and the formation of leads. Lead formation during periods of divergent motion produce open water and thin ice areas that dominates the heat flux into the atmosphere and salt flux into the ocean. Pressure ridges are formed during periods of ice convergence. These processes control the extremes in the thickness distribution of the sea ice cover. Here, we describe our current observational capability in sampling these processes in space and time. (Received September 15, 2008)

1046-86-1569 **Elchin E Jafarov*** (fteej@uaf.edu), PO BOX 750686, Fairbanks, AK 99775, **Dmitry J Nicolsky** (ftdjn@uaf.edu), Geophysical Institute, PO BOX 757320, Fairbanks, AK 99775, **Victor S Mikhaylov** (ftvsm@uaf.edu), 101 Chapman hall, Fairbanks, AK 99775, and **Vladimir E Romanovsky** (ffver@uaf.edu), Geophysical Institute, PO BOX 757320, Fairbanks, AK 99775. *Inverse problem of heat conduction, reconstruction of the temperature profile.*

Quantitative reconstruction of the temperature field backwards in time requires a numerical tool for solving the inverse problem of heat conduction in fully saturated soils. In this paper we present a variational approach to one-dimensional numerical restoration of thermo-conductive heat flow with temperature-dependent conductivity, heat capacity and volumetric water content. This approach is based on a search for the soils temperature by minimizing differences between present-day temperature measured by installed temperature sensors and the predicted by forward model of heat flow for an initial temperature guess. To demonstrate the applicability of this technique, we show that the initial temperature profile of the heat flow can be numerically reconstructed with some allowed inaccuracy from the true initial distribution. (Received September 16, 2008)

1046-86-1620 **Jerry L. Bona*** (bona@math.uic.edu), Dept. Mathematics, Statistics & Computer Sci., 851 S. Morgan Street MC 249, Chicago, IL 60607. *Computational Methods in Coastal Engineering.*

This lecture deals with questions arising in coastal engineering. We indicate how classical scientific computation can impact coastal engineering practice, such as the design of beach protection strategies. (Received September 16, 2008)

1046-86-1659 **Elaine T. Spiller*** (elaine.spiller@marquette.edu), Dept of Math, Stat, and CS, Cudahy Hall, 322, P.O. Box 1881, Milwaukee, WI 53201-1881. *Constructing a Risk Map for Pyroclastic Flows: Using simulations and data to predict rare events.*

Large pyroclastic flows are rare yet potentially devastating events for communities situated near volcanoes. The volume of flow-events follows an α-stable distribution meaning that large events, which can lead to catastrophic damage, must be taken into account for civil protection purposes. We propose a method to draw hazard maps that combines field data, digital elevation maps, and flow simulations. As a test case, we focus on calculating probabilities of catastrophic damage due to flow events from the Soufriere Hills Volcano on the island of Montserrat. (Received September 16, 2008)

1046-86-2074 **Benjamin J Galluzzo*** (bgalluzz@math.uiowa.edu), Department of Mathematics, MacLean Hall, University of Iowa, Iowa City, IA 52242. *Parameter Determination for Subsurface Fluid Flow Modeling.* Preliminary report.

Subsurface fluid flow modeling is dependent on understanding the permeability of geologic media. However, the intrinsic heterogeneity of the subsurface severely limits the effectiveness of many such models. Analytic solutions simplify the problem by assuming homogeneity, while some models presume reasonable subsurface characterization impossible and in turn, employ a random field. In this talk we will discuss our method for subsurface mapping; specifically our approach to solving the inverse problem as it relates to the transient saturated flow equation in hydrogeology. We will also present a numerical simulation as well as a comparison between numerical and experimental results. (Received September 17, 2008)

1046-86-2111 **Rafail V. Abramov*** (abramov@math.uic.edu), MSCS, University of Illinois at Chicago, 851 S. Morgan st., Chicago, IL 60607, and **Andrew J. Majda**, Courant Institute of Mathematical Sciences, New York University, 251 Mercer st., New York, NY 10012. *Climate response through fluctuation-dissipation: A new algorithm for low-frequency dynamics.*

Recently, we developed and tested a novel computational algorithm for predicting the mean response of a chaotic dynamical system to small changes in external forcing via the fluctuation-dissipation theorem (FDT). Unlike the earlier work in developing FDT-based computational strategies for chaotic nonlinear systems with forcing and dissipation, the new method is based on the theory of SRB probability measures, which commonly describe equilibrium states of such dynamical systems. The new response algorithm is tested on a model of the barotropic climate with realistic Earth orography and forcing mimicking the dynamics of the atmosphere at 300 and 500 hPa geopotential height. The new method yields greater accuracy than the classical FDT method for the response of both mean state and variance for large scale EOFs. These results point the way toward the potential use of the new response algorithm in operational long-term climate change prediction. (Received September 17, 2008)

90 ► Operations research, mathematical programming

1046-90-48 **Victor Goodman*** (goodmanv@indiana.edu), Mathematics Department, Indiana University, Bloomington, IN 47405. *Volatility Models of the Yield Curve.*

An interesting and useful class of multi-factor term structure models is formed by specifying common volatilities for forward interest rates. The context is not HJM since it is well known that constant volatility in an HJM model produces infinite rates. On the other hand, if one solves for the arbitrage-free dynamics in terms of a forward measure, one finds that rates are finite up to the maturity of the numeraire. Basic derivatives may be priced using this approach, even though the risk-neutral and forward measures are not equivalent. We present specific prices for caps and swaptions; these results allow one to compute hedging positions. Also, we describe the structure of a three-factor model which best implements the observed statistics of rates, and we indicate some open problems remaining for this class of models. (Received July 08, 2008)

1046-90-381 **Anton Abdulbasah Kamil*** (anton@usm.my), School of Distance Education, Universiti Sains Malaysia, 11800 Penang, Penang, Malaysia, **Adli Mustafa** (adli@cs.usm.my), School of Mathematical Sciences, Universiti Sains Malaysia, 11800 Penang, Penang, Malaysia, and **Khlipah Ibrahim** (khalipah60@yahoo.com), School of Distance Education, Universiti Sains Malaysia, 11800 Penang, Penang, Malaysia. *Stochastic Optimization For Portfolio Selection Problem With Mean Absolute Negative Deviation Measure.*

Portfolio optimization has been one of the important research fields in financial decision making. The most important character within this optimization problem is the uncertainty of the future returns. To handle such problems, we utilize probabilistic methods alongside with optimization techniques. We develop single stage and two stage stochastic programming with recourse for risk-averse investors and the objective of the stochastic programming models is to minimize the mean absolute negative deviation. We use the so-called "Here-and-Now" approach where the decision-maker makes decision "now" before observing the actual outcome for the stochastic parameter. We compare the optimal portfolios between the single stage and two stage models that hedge against the risk of investment. These models are applied to the optimal selection of stocks listed in Bursa Malaysia and

the return of the optimal portfolio is compared between the two stochastic models. The results show that the optimal portfolios of the two stage model out performs the single stage model. (Received August 29, 2008)

1046-90-666 **Oleg Roderick*** (roderick@mcs.anl.gov), **Mihai Anitescu** and **Paul Fischer**.
Uncertainty Quantification: Improved Stochastic Finite Element Approach.

We introduce a stochastic finite element-based approach to describing the uncertainty of a complex system of differential-algebraic equations with random inputs.
For our test system, we take a 3-dimensional steady-state model of heat distribution in the core of a nuclear reactor. The dependence of the material properties of the reactor on temperature includes uncertainty.
We solve the corresponding problem of uncertainty quantification through the creation of a valid simplified version of the system. We construct this surrogate model as a goal-oriented projection onto an incomplete space of interpolating polynomials; find the coordinates of the projection by collocation; and use derivative information to reduce the number of the required collocation points. The basis is trimmed to linear functions in some variables, and extended to high order polynomials in the others, depending on relative importance. Derivatives of the output with respect to random parameters are obtained using an adjoint method with elements of automatic differentiation.
The resulting model is more computationally efficient that random sampling, or generic stochastic finite element method; and has significantly greater precision than linear models. (Received September 09, 2008)

1046-90-819 **John F Shortle*** (jshortle@gmu.edu), 4400 University Dr., MS 4A6, Fairfax, VA 22030, **Martin J. Fischer** (mfischer@noblis.org), 3150 Fairview Park Drive South, Falls Church, VA 22042, and **Denise M. B. Masi** (dmasi@noblis.org), 3150 Fairview Park Drive South, Falls Church, VA 22042. *Simulation Techniques and Numerical Methods for Analyzing Systems with Heavy-Tailed Distributions.*

Many systems that involve heavy-tailed distributions are difficult to analyze analytically. The presence of heavy tails often presents challenges that do not exist for similar systems without heavy tails. This talk presents an overview of some of these issues as well as numerical methods and simulation techniques for addressing the problems. For example, G/G/1 queues, which have applications in telecommunications and insurance-risk modeling, pose challenges for simulation when the underlying distributions are heavy-tailed. We investigate why this may be so. Even if we are willing to consider truncated distributions (as a way to model some large but finite maximum for the distributions in question), there still can be problems in simulating if the truncation point is too large. Simulation techniques, such as importance sampling, and other numerical techniques to address these issues are discussed. (Received September 11, 2008)

1046-90-1288 **Jungmin Choi*** (choi@math.fsu.edu), Department of Mathematics, 208 LOVE Building, 1017 Academic Way, Tallahassee, FL 32306-4510, and **Max Gunzburger**. *Option Pricing in the Presence of Random Arbitrage Return.*

We consider option pricing problems when we relax the condition of no arbitrage in the Black Scholes model. The derived pricing equation is in the form of Stochastic Partial Differential Equation (SPDE). We used Karhunen-Loève expansion to approximate the stochastic term, and the numerical solution of the SPDE is computed using Finite Element Method. (Received September 15, 2008)

1046-90-1450 **Sasha F Stoikov*** (sashastoikov@gmail.com), 85 E. 10th st (apt 5K), New York, NY 10003, and **Rama Cont** (rama.cont@gmail.com) and **Rishi Talreja** (rt2146@columbia.edu). *A Markov Model for the Dynamics of a Limit Order Book.*

We model a limit order book as a continuous-time Markov process that tracks the number of limit orders at each price level. Our model strikes a balance between three desirable features: its parameters are easily estimated from high-frequency data, it captures key empirical properties of order book dynamics and its analytical tractability allows for efficient computation of quantities of interest in applications. Laplace transform methods allow for fast numerical computation of conditional probabilities of various events: an increase in the mid-price, execution of an order at the bid before the ask quote moves, execution of both a buy and a sell order at the best quotes before the price moves. We describe a parameter estimation procedure based on high-frequency observations of the first k levels of bids and asks and illustrate the results on data from the Tokyo stock exchange. Simulations of the estimated model show a favorable comparison of various statistical properties with empirically observed ones. (Received September 15, 2008)

1046-90-1592 **Micah Altman*** (micah_altman@harvard.edu), 1737 Cambridge St. # 325, Cambridge, MA 02145. *The Promises and Perils of Optimal Redistricting.*

Attempts to rigidly apply simple rules to the creation of districts will often have unintended political consequences when politics, the law, geography, mathematics,and computation interact. Redistricting is a political activity that conducted at the juncture of these fields, underpinned by philosophical understandings of political representation,and measurable primarily through statistics. It is perhaps unsurprising that there remains much disagreement over the goals, processes, and outcomes of redistricting.

Over the last fifty years there have been repeated scholarly attempts to remove politics from redistricting (and partisan attempts to create the ultimate gerrymander) by applying combinatoric optimization techniques to the problem of drawing electoral boundaries. In this presentation, I discuss the frontiers of this approach to redistricting, along with its specific technical and broader theoretical limitations. (Received September 16, 2008)

1046-90-1976 **Rommel G Regis*** (rregis@sju.edu), Saint Joseph's University, Math & CS Dept., 5600 City Avenue, Philadelphia, PA 19131. *On the Convergence of Adaptive Stochastic Search Methods for Continuous Global Optimization.*

There are many results on the convergence of stochastic search methods for continuous global optimization. However, most of these convergence conditions are cumbersome to verify for algorithms that are used in practice. Moreover, some of these convergence results only apply to uniform distributions. This talk will present some simple convergence conditions for a general class of adaptive stochastic global optimization algorithms. In addition, this talk will also present a convergence result on global optimization algorithms that utilize elliptical distributions such as the multivariate Gaussian and Cauchy distributions. (Received September 16, 2008)

91 ► Game theory, economics, social and behavioral sciences

1046-91-94 **Ahmet Duran*** (durana@umich.edu), University of Michigan-Ann Arbor, Department of Mathematics, 530 Church Street, Ann Arbor, MI 48109. *Sensitivity analysis of asset flow differential equations and a new volatility approach.*

A sensitivity analysis is applied to the dynamical system of nonlinear asset flow differential equations (AFDE). I find that all parameters in AFDE are needed and estimate all parameters of the microeconomic model from market prices and net asset values data. My results are consistent with the previous studies in the asset flow theory developed by Caginalp and collaborators since 1989. Moreover, a new volatility approach is defined and analyzed. After the analytical and numerical findings, I will present my empirical results for the set of 52 closed-end funds (CEFs) trading in US markets by using the daily closing prices during 1 April 1998 to 31 March 2008. (Received July 22, 2008)

1046-91-102 **Karl-Dieter Crisman*** (karl.crisman@gordon.edu). *Undergraduate research in the mathematics of voting and choice using Sage.* Preliminary report.

The mathematics of voting and choice is a good way to draw talented undergraduates into research in the mathematical sciences. We describe an REU in this field where use of open source mathematical software (specifically, Sage) led to more rapid progress in research, and suggest directions for further integrating open source software and this increasingly computational area. (Received July 22, 2008)

1046-91-182 **Roger W. Barnard** (roger.w.barnard@ttu.edu), Department of Mathematics, Texas Tech University, Lubbock, TX 79409, **Michael B. Gordy*** (Michael.Gordy@frb.gov), Division of Research & Statistics, Board of Governors, Federal Reserve System, Washington, DC 20551, and **Kendall C. Richards** (richards@southwestern.edu), Department of Mathematics, Southwestern University, Georgetown, TX 78626. *A Turán Type Inequality for the Kummer Function Arising in Finance. Part I: The Application.*

When the value of a firm's assets V follows a geometric Brownian motion, the value of a perpetual debt contract as a function $F(V;\kappa)$ solves Kummer's differential equation with a boundary condition depending on the firm's bankruptcy threshold κ. We model a lending relationship in which covenants to the loan contract permit the bank to choose the bankruptcy threshold. The bank's optimal choice of κ solves a first order condition involving a ratio of contiguous Kummer functions. This implies that the Turán-type inequality for the Kummer function

$\Phi(\alpha,\beta,x) \equiv \sum_{n=0}^{\infty} \frac{(\alpha)_n x^n}{(\beta)_n n!}$ arises naturally in studying the comparative statics of the model:

$$\Phi(a,a+b,x)^2 > \Phi(a+1,a+b,x)\Phi(a-1,a+b,x)$$

for all nonzero $x \in \mathbb{R}$ and $a,b>0$. (Received August 13, 2008)

1046-91-512 **Kasper Larsen*** (kasperl@andrew.cmu.edu), Kasper Larsen, Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213. *A note on the existence of the power investor's optimizer.*

KLSX (1991) ensure the existence of the expected utility maximizer for investors with constant relative risk aversion coefficients less than one. In this note, we explain a simple trick that allows us to use this result to provide the existence of utility maximizers for arbitrary coefficients of relative risk aversion. The simplicity of our approach is to be contrasted with the general existence result provided in KS (1999). (Received September 05, 2008)

1046-91-630 **Robert W. McKelvey*** (RWMcKelvey@msn.com), 1740 Madeline Avenue, Missoula, MT 59801. *Decentralized Multinational Management of a Highly Migratory Marine Fish Stock.*

Many valuable harvested marine fish stocks, such as swordfish and many species of tuna, are classified as "highly migratory". That is, their range is vast, including thousands of miles of international waters and intersecting the "extended economic zones" of many coastal countries. Furthermore, the fishing fleets that harvest such a stock may represent many additional countries, often far distant from the range of the harvested fish stock.

It is well understood (i.e. the "tragedy of the common") that these multinational "stakeholders" must coordinate their harvest policies to avoid overharvesting and achieve long-term bioeconomic sustainability of the fishery.

Worldwide, multinational "regional fishery management commissions" (RFMCs) have been created within which these stakeholders negotiate the terms of their policy coordination and the mechanisms for achieving their agreed goals. Some of these commissions have been effective in carrying out these responsibilities, but too many have not.

Here I describe a multidisciplinary study, based on game theoretic analysis, of the operation of such a RFMC-managed fishery, comparing the effectiveness of alternative management policies and mechanisms, especially in an environment of uncertain and incomplete information. (Received September 09, 2008)

1046-91-680 **Zeph Landau*** (zeph.landau@gmail.com), Department of Computer Science, 387 Soda Hall, University of California, Berkeley, CA 94720-1776, and **Ilona Yershov** and **Oneil Reid**. *A Fair Division Solution to the Problem of Redistricting.*

Redistricting is the political practice of dividing states into electoral districts of equal population in response to decennial census results to ensure equal representation in the legislative body. Where the boundaries are drawn can dramatically alter the number of districts a given political party can win. As a result, a political party which has control over the legislature, can (and does) manipulate the boundaries to win a larger number of districts, thus affecting the balance of power in the U.S. House of Representatives.

This work introduces a novel solution to the problem of fairly redistricting a state that is motivated by the ideas of fair division. Instead of trying to ensure fairness by restricting the shape of the possible maps or by assigning the power to draw the map to nonbiased entities, this solution ensures fairness by balancing competing interests against each other. Essentially, it is a simple interactive protocol that presents two parties with the opportunity to achieve their fair representation in a state (where the notion of fairness is rigorously defined) and as a result a balanced electoral map is created. (Received September 10, 2008)

1046-91-744 **Steven Kou*** (sk75@columbia.edu), 312 Mudd Building, Dept. of IEOR, Columbia University, New York, NY 10027. *The Recent Financial Turmoil and Related Research Problems.*

The past several months have been an eventful period for the U.S. financial markets, mainly due to the crisis in subprime credit markets and the difficulty in modeling collateralized debt obligations (CDOs). In this talk we will present two of financial engineering problems that are related to the recent financial turmoil: (1) How to model CDOs by incorporating clustering defaults? We propose a new model based on Polya processes and the cumulative intensity of counting processes that can calibration the current CDO data very well. (2) What are good external risk measures for the financial regulators? We propose a new axiomatic approach to justify the current governmental regulations, by using axioms from robust statistics and the separation by hyperplanes from functional analysis. (Received September 10, 2008)

1046-91-759 **Gordan Zitkovic*** (gordanz@math.utexas.edu), University of Texas at Austin, Department of Mathematics, 1 University Station, C1200, Austin, TX 78712. *Stability and equilibria of financial markets.* Preliminary report.

Risk can rarely be hedged away completely and, consequently, a financial valuation paradigm beyond classical, perfect-hedge-based Black-Scholes-type procedures is needed. Economists have been solving equilibrium problems for more then a century now, and I will try to argue how their methods, combined with some recent progress can be used not only to come up with new pricing methods, but also to generate interesting mathematics. (Received September 10, 2008)

1046-91-834 **Andrew Gelman*** (gelman@stat.columbia.edu), Dept of Statistics, Columbia Univ, New York, NY 10027, and **David Epstein**, Dept of Political Science, Columbia Univ, New York, NY 10027. *Partisan Fairness in Districting.* Preliminary report.

A basic principle of fairness is legislative districting is partisan symmetry: the expected number of seats that party A receives given X% of the vote should be the same as the expected number of seats that party B would receive if it received X%. We discuss applications of this principle and two places where it breaks down or needs to be extended: (1) settings where parties are geographically distributed in dissimilar ways, and (2) settings where it is not plausible that the two parties will get the same share of the vote. (Received September 11, 2008)

1046-91-917 **Daniel H Ullman*** (dullman@gwu.edu), Department of Mathematics, The George Washington University, 2115 G Street NW, Room 273, Washington, DC 20052. *The Mathematical Redistricting Problem.* Preliminary report.

We explore a variety of mathematical formalizations of the redistricting problem, the problem of drawing congressional district lines. We consider both continuous (geometric) and discrete (combinatorial) models. In both cases, we consider an array of interpretations for "compact and contiguous", an ill-defined legal requirement for the blocks in a redistricting plan. Under the various interpretations, we investigate algorithms for arriving at an appropriate or optimal partition. While these formalizations model the real-world redistricting problem in only the crudest way, it is possible for these analyses to play a role in the improvement of our current political systems for redistricting. (Received September 12, 2008)

1046-91-947 **Jonathan N. Katz*** (jkatz@caltech.edu), Caltech, DHSS 228-77, Pasadena, 91125, and **Andrew Gelman** and **Gary King**. *A New Approach to Measuring the Racial Impact of Redistricting.*

Since the passage of the Voting Rights Act in 1965, race has played a central role in drawing legislative district boundaries in the U.S. Most of the academic and popular debate on "racial redistricting" has focused on the creation and impact of so-call "majority-minority" districts. While this debate has been informative, much of it does not address absolute standards for the racial fairness of a proposed (or enacted) legislative map. We offer here a framework and method for directly estimating the immediate quantity of interest: the racial fairness of a redistricting plan, and one that would seem to be consistent with U.S. Constitution and legal doctrine. It is also practical, estimable, and easy to apply. Our measure of racial fairness is based the the probability that a given voter will cast a decisive ballot in an election — i.e., change the outcome of the election — which we will also call voting power. By considering individuals' voting power, a natural definition of racial fairness arises. We show how to estimate this notion of racial fairness from observed election data using extensions of standard statistical techniques. This should allow one to make valid statistical inferences about the likely impact of proposed redistricting plans. (Received September 12, 2008)

1046-91-1095 **Anirban Dutta*** (anirban.dutta@wmich.edu), Department of Mathematics, Western Michigan University, Kalamazoo, MI 49008-5248, and **Qiji J. Zhu** (qiji.zhu@wmich.edu), Department of Mathematics, Western Michigan University, Kalamazoo, MI 49008-5248. *Stable trading strategy involving several options.*

Given any reasonable investment system and a call option on it, it is shown by Zhu that it can be improved by a stable trading strategy which involves switching between buying the asset, buying the call option or writing a call option depending on the premium of the option. It is shown that there is a range of premium where the asset performs better than the option systems. In this project, we generalize this to one asset and several call options on it. We show that the stable strategy is a switch between buying the asset, buying one option, writing one option or a vertical spread. The switch depends on the premiums of the options. We see that there is also a region of option premiums such that the original asset performs better than any of the option systems. (Received September 14, 2008)

1046-91-1115 **Ryan Lewis*** (me@ryanlewis.net), School of Mathematical Sciences, 85 Lomb Memorial Drive, Rochester Institute of Technology, Rochester, NY 14623, and **Anthony Harkin** (aahsma@rit.edu), School of Mathematical Sciences, 85 Lomb Memorial Drive, Rochester Institute of Technology, Rochester, NY 14623. *A Network Theoretic Approach to Hyperspectral Image Classification.*

A hyperspectral image has n pixels with $k > 100$ spectral bands. Hyperspectral imaging has a variety of applications, for example: geological research, wetlands mapping, and plant and mineral identification. We present a novel technique to classify the pixels of a hyperspectral image into spectrally similar groups. Our method represents the image data as a subset of R^k, and is based on Newman's Method of Optimal Modularity in Social Networks. (Received September 14, 2008)

1046-91-1166 **Christopher P. Chambers**, CA , and **Alan D Miller*** (alan@hss.caltech.edu), Mail Code 228-77, Caltech, Pasadena, CA 91125-7700. *A Measure of Bizarreness.*

We introduce a path-based measure of convexity to be used in assessing the compactness of legislative districts. Our measure is the probability that a district will contain the shortest path between a randomly selected pair of its' points. The measure is deﬁned relative to exogenous political boundaries and population distributions. (Received September 15, 2008)

1046-91-1297 **Albina Danilova*** (danilova@andrew.cmu.edu), Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213-3890. *Stock Market Insider Trading in Continuous Time with Imperfect Dynamic Information.*

In this talk I will present a model of the equilibrium pricing of asset shares in the presence of dynamic private information. The market consists of a risk-neutral informed agent who observes the firm value, noise traders, and competitive market makers who set share prices using the total order flow as a noisy signal of the insider's information. I provide a characterization of all optimal strategies, and prove existence of both markovian and non markovian equilibria by deriving closed form solutions for the optimal order process of the informed trader and the optimal pricing rule of the market maker. The consideration of non markovian equilibrium is relevant since market maker might decide to re-weight past information after recieving a new signal. Also, I show that a) there is a unique markovian equilibrium price process which allows the insider to trade undetected, and that b) the presence of an insider increases the market informational efficiency, in particular for times close to dividend payment. (Received September 15, 2008)

1046-91-1432 **Scott Duke Kominers*** (kominers@fas.harvard.edu), 8520 Burning Tree Road, Bethesda, MD 20817. *Clubs, Beliefs, and Entrapment.*

Dixit introduced a game-theoretic model of club formation in which network effects lead to entrapment of the entire community. Although Dixit's model appropriately models many types of entrapping clubs, its assumptions are too stringent in the important case of technology adoption.

To model entrapment in this situation, we develop a simple game-theoretic model of club formation under uncertainty. In our framework, the entire community might prefer the status quo to club membership, but there is some uncertainty regarding the likelihood that a club will form. Within this setting, beliefs become self-fulfilling prophesies and communities may freely adopt clubs against their best interests. Dynamics may reinforce or lessen these effects. (Received September 15, 2008)

1046-91-1485 **Eric A Gilson*** (eagilson@gmail.com), University of Rochester, CPU Box 275480, Rochester, NY 14627, **Chelsey A Cooley** (cacooley@ncsu.edu), 1717-d Simpkins Street, Raleigh, NC 27606, and **William M Ella** (wella9cd@umw.edu), **Micheal L Follett** (follettm@lafayette.edu) and **Lorenzo Traldi** (traldil@lafayette.edu). *Dice Voting: A Deterministic Method for Aggregating Pairwise Preferences.* Preliminary report.

Arrow's theorem rules out the possibility of finding a perfect voting system, so it is important to understand many systems and their properties. In this talk we will present some interesting properties of the dice voting system. In this system each candidate is represented by a die; each side of the die has one voter's Borda score for that candidate. Candidate A is stronger than Candidate B if the probability that Candidate A's die rolls a higher value than Candidate B's is greater than the probability that Candidate B's die rolls a higher value than Candidate A's. This system has many properties in common with the Borda and Condorcet systems without being identical to either. The most interesting property is given an outcome for a set of candidates, the possible outcomes for restrictions in the set of candidates has many of the same relations as the Borda Count. (Received September 15, 2008)

1046-91-1498 **Michael P McDonald*** (mmcdon@gmu.edu), 4400 University Drive, 3F4, Fairfax, VA 22030-4444. *The Redistricting Problem: Second-Order Bias.* Preliminary report.

Those who propose gerrymandering solutions often assert that following a well-defined set of "neutral" criteria will result in fair districts. A two-year mapping project of over 14,000 legislative districts in five Midwestern states demonstrates that seemingly-neutral criteria can have second-order bias, in that criteria often produce districts that can favor a political party. This mapping project further reveals that simple heuristics, for example drawing compact districts, fail to account for practical legal and election administration considerations, such as respecting the Voting Rights Act and maintaining the integrity of city and county boundaries. (Received September 15, 2008)

1046-91-1547 **Timothy C Reluga*** (timothy@reluga.org), Department of Mathematics, McAllister Hall, University Park, PA 16901-6401. *Rational behavior in response to pandemic influenza, and consequences for control.* Preliminary report.

The prospect of pandemic influenza is an ongoing concern in national disaster preparation, and one which has inspired several notable modelling efforts. One crucial feature needed in these models is some prediction of how peoples behaviors will change in response to an ongoing pandemic. In this talk, I'll describe new research into the application of optimal control theory in combination with recent advances in public health game theory for the calculationa of rational-expectation equilibria in dynamics games for pandemics. Numerical methods used to solve this problem combine non-standard finite difference methods with nonlinear multigrid methods. I'll then demonstrate how the use of this and related approaches will help predict policy resistance and may lead to better control. (Received September 16, 2008)

1046-91-1603 **Gregory Minton*** (gminton@hmc.edu). *Studying Voting Paradoxes Through Representation Theory.*

Voting theory is plagued with paradoxes: with a fixed set of voter preferences, the winner of an election may change if the voting system in use changes. Certain types of voting systems, the so-called positional maps, have symmetries that make them easily understood through the representation theory of the symmetric group. In this talk, I will discuss the paradoxes that arise with positional voting maps when candidates drop out of an election. This was joint work with the Applied Representation Theory group at Harvey Mudd College. (Received September 16, 2008)

1046-91-1674 **Sam Hirsch*** (shirsch@jenner.com), Jenner & Block LLP, 1099 New York Avenue, NW, Washington, DC 20001. *A Proposal for Redistricting Reform: A Model State Constitutional Amendment.*

Calls for judicial intervention to cure the evils of gerrymandering are legion. But surprisingly little attention has been paid to institutional design: Who should redraw districts, and under what rules? This Paper rejects the notion that redistricting reform should aim to depoliticize the process by denying redistricters access to political data. Instead, states should require redistricting commissions to engage in an iterative process that forces each major political party to compete by presenting a plan with more geographic integrity, more competitive districts, and less partisan bias than the plan last proposed by the other party. (Received September 16, 2008)

1046-91-1791 **Anthony Tongen*** (tongenal@jmu.edu), Department of Mathematics and Statistics, MSC 1911; James Madison University, Harrisonburg, VA 22807, and **D Brian Walton**, **Deena Hannoun** and **Leslie Hindman**. *An Optimal Strategy for Energy Allocation in a Multiple Resource Environment.* Preliminary report.

We use difference equations to model a population with overlapping generations that invests energy into finding two resources essential for its survival. This population is divided into two competing subpopulations that have different energy allocation strategies for a limited amount of available resources in the environment. The goal of this project is to discover how a subpopulation can divide its energy most effectively between the two resources such that it can have more reproductive success than its competitor and can consequently dominate its niche. (Received September 16, 2008)

1046-91-1888 **Daniel L. Goroff***, 317 West 76th Street #4R, New York, NY 10023. *Continuing Discussion of the Redistricting Problem.* Preliminary report.

Discussion of the Redistricting Problem as a mathematical, legal, and political challenge. (Received September 16, 2008)

1046-91-2101 **James M Snyder***, E53-457, Cambridge, MA 02139. *Empirical Consequences of Redistricting in the U.S.*

In principle, redistricting can be used to help incumbents, reduce electoral competition, bias outcomes in favor of a party, or favor or hurt particular groups of voters. We examine the degree to which redistricting in the U.S. does any of these, paying particular attention to incumbents and parties. (Received September 17, 2008)

92 ► Biology and other natural sciences

1046-92-74 **David M Chan*** (dmchan@vcu.edu), Department of Mathematics, 1001 West Main Street, Richmond, VA 23284, **Rodney J Dyer** (rjdyer@vcu.edu), Department of Biology, 1000 West Cary Street, Richmond, VA 23284, and **Erich Foster**, **Alex Feild** and **April McFarland**. *Gene Dispersal in an Insect Pollinated Tree Species.* Preliminary report.

Understanding the methods by which genes are distributed across a landscape is critical in the managment of species. Here we present an agent based model describing pollen-mediated gene flow for both wind and animal mediated dispersal. We use this model to estimate expectations of dispersal distance and pollinator search area for both correlated and uncorrelated random walks. We also introduce variation in plant density to quantify density-dependent dispersal. In general, we find that correlated random walks, as expected for animal dispersal, result in significantly different patterns of gene dispersal across the landscape. (Received July 21, 2008)

1046-92-78 **Majid Masso*** (mmasso@gmu.edu), 10900 University Blvd., MS 5B3, Manassas, VA 20110. *Computational Mutagenesis for Analysis of Protein Functional Changes Upon Mutation.* Preliminary report.

Proteins are the workhorse macromolecules of all organisms, performing a myriad of essential structural, regulatory, and catalytic tasks. Experimental discoveries related to mechanisms underlying protein structure and function are frequently made by analyzing the effects of amino acid residue substitutions at targeted positions. While such work is invaluable for design and engineering of new proteins with desired properties, it is also expensive and time consuming, leading to greater demand for reliable predictive models. Here we present a computational mutagenesis that empirically assesses relative change to overall protein structure due to residue replacements (residual score), and locally quantifies associated environmental perturbations at all positions (residual profile). Our approach utilizes a four-body, knowledge-based, statistical contact potential derived by applying Delaunay tessellation to a diverse dataset of protein structures. We illustrate how computed mutant residual scores correlate well with experimental relative functional changes, complementing the inherent nature of protein structure-function relationships. Additionally, residual profiles are used to develop accurate predictive models of mutant function through implementation of machine learning algorithms. (Received September 09, 2008)

1046-92-89 **Lauren E Pace*** (pacele@vcu.edu) and **John W Cain** (jwcain@vcu.edu), Department of Mathematics, Box 842014, Virginia Commonwealth University, 1001 West Main Street, Richmond, VA 23284-2014, and **Dewey T Taylor** (dttaylor2@vcu.edu), Department of Mathematics, Box 842014, Virginia Commonwealth University, 1001 West Main Street, Richmond, VA 23284-2014. *Modeling the Dynamics of Feed-Forward Biological Networks.*

Many important biological pathways, including apoptosis and glycolysis, are feed-forward in the sense that they can be rendered as directed graphs without any directed cycles. The structure of such networks may vary from organism to organism, and it is of great interest to determine (i) the effect of network topology on the overall speed/efficiency of the network and (ii) whether speed may convey evolutionary advantages. Modeling the dynamics of feed forward networks typically involves solving systems of ordinary differential equations.

As a first step toward ranking the efficiency of various network topologies, we seek classes of non-isomorphic networks which, nonetheless, exhibit the same dynamics; such networks are called isodynamic. In this talk, we shall present several theoretical results, proving that certain classes of networks are isodynamic. For example, consider the class of all feed-forward networks with (i) no isolated vertices; (ii) precisely one "source" vertex (i.e., indegree zero); and (iii) precisely one "target" vertex with indegree $n-1$ and outdegree zero. We prove that, if all reaction rate constants are identical, then all such networks are pairwise isodynamic. (Received July 22, 2008)

1046-92-162 **Ariel Cintron-Arias*** (acintro@ncsu.edu), Center for Research in Scientific Computation, North Carolina State University, P.O. Box 8212, Raleigh, NC 27695-8212. *The Estimation of the Effective Reproductive Number from Disease Outbreak Data.*

We consider a single outbreak Susceptible-Infected-Recovered (SIR) model and corresponding estimation procedures for the effective reproductive number $\mathcal{R}(t)$. We discuss the estimation of the underlying SIR parameters with a generalized least squares (GLS) estimation technique. We do this in the context of appropriate statistical models for the measurement process. We use asymptotic statistical theories to derive the mean and variance of the limiting (Gaussian)sampling distribution and to perform post statistical analysis of the inverse problems. We illustrate the ideas and pitfalls (e.g., large condition numbers on the corresponding Fisher information matrix) with both synthetic and influenza incidence data sets. (Received September 03, 2008)

1046-92-253 **Zijie Liao** (zliao@wpi.edu), Mathematical Sciences Department, Worcester Polytechnic Institute, 100 Institute Road, Stratton Hall 108, worcester, MA 01609, **Xueying Huang*** (xueying@wpi.edu), Mathematical Sciences Department, Worcester Polytechnic Institute, 100 Institute Road, Stratton Hall 108, worcester, MA 01609, **Chun Yang** (yangchun@bnu.edu), School of Mathematical Sciences, Beijing Normal University, Beijing, 100875, Peoples Rep of China, and **Dalin Tang** (dtang@wpi.edu), Mathematical Sciences Department, Worcester Polytechnic Institute, 100 Institute Road, Stratton Hall 108, worcester, MA 01609. *3D In Vivo MRI-Based FSI Models for Human Carotid Atherosclerotic Plaques and Patient-Specific Plaque Progression Growth Functions with Validation.*

Mechanisms governing atherosclerotic plaque rupture and progression are not well understood. The purpose of this research is to identify mechanical factors which may contribute to plaque progression and quantify patient-specific plaque growth functions by using 2D and 3D multi-component plaque models with fluid-structure interactions (FSI) based on serial MRI data taken from patients at multiple time points. 2D and 3D numerical models were constructed to obtain flow and stress/strain data. Four 3D plaque growth functions were obtained using flow shear stress and structure stress from Time 1 and 2. Those growth functions were used to predict plaque progression at Time 3. Predicted plaque progression was compared with actual MRI data at Time 3 for validation. Our results indicated that 3D FSI model gave better predictions for plaque progression than either 3D wall-only/fluid-only or 2D solid models. Large-scale long-term patient studies are needed to further validate our findings. Acknowledgement: This research was supported in part by NSF grant DMS-0540684 and NIH grant R01 EB004759. MRI data was provided by Dr. Chun Yuan and his group from University of Washington Medical School. (Received August 23, 2008)

1046-92-264 **Abra Brisbin*** (agb36@cornell.edu), 657 Rhodes Hall, Cornell University, Ithaca, NY 14853, **Jason Mezey** (jgm45@cornell.edu), 101 Biotechnology Bldg, Cornell University, Ithaca, NY 14853, and **Carlos Bustamante** (cdb28@cornell.edu), 102 Weill Hall, Cornell University, Ithaca, NY 14853. *Linkage Analysis for Categorical Traits on Complex Pedigrees.*

Linkage analysis, the use of pedigree data to identify genes, has traditionally been used for analysis of binary or continuous traits. We will present a statistical framework for analysis of categorical traits, employing a novel estimator for parameter inference from Markov chain Monte Carlo. We will demonstrate the value of our method by analyzing candidate genes for cardiac arrhythmia in a pedigree of German Shepherd dogs. (Received September 10, 2008)

1046-92-273 **Nessy Tania*** (tania@math.utah.edu), Department of Mathematics, University of Utah, 155 S. 1400 E. Rm.233, Salt Lake City, UT 84112-0090, and **James P Keener**. *The Effect of Diffusion on Calcium Oscillations.* Preliminary report.

Ordinary differential equation models are widely used to study IP3-mediated calcium oscillations. There, a cell is taken as a well-mixed compartment, but experiments often show spatial inhomogeneity in intracellular [Ca]. Using a spatially extended model, we study how diffusion affects calcium release. It lowers the [Ca] at a particular release site while increasing the concentration at neighboring sites. Varying the diffusion coefficient can significantly change the bifurcation point for oscillation onset. (Received August 25, 2008)

1046-92-306 **Franziska B. Hinkelmann*** (fhinkel@vt.edu), 204 Church Street Apt. 2, Blacksburg, VA 24060. *A General Method to derive a Boolean Model from a Continuous Model for Gene Regulatory Networks.*

Traditionally gene regulation is modeled by ordinary differential equations and the solutions are tested against experimental data. Gene regulatory networks behave like a Boolean switching network (Kauffman 1969), therefore it is intuitive to model them with a Boolean network. We describe a method that transforms a system of differential equations into a Boolean network and is guaranteed to maintain the dynamics of the system. (Received September 10, 2008)

1046-92-317 **Thomas Keef*** (tk506@york.ac.uk), Department of Mathematics, University of York, Heslington, York, YO10 5DD, England, and **Reidun Twarock** (rt507@york.ac.uk), Department of Mathematics, University of York, Heslington, York, YO10 5DD, England. *Hidden symmetries in virus architecture and their implications on virus assembly.*

It has long been recognised that viruses use icosahedral symmetry in the structural organisation of their protein containers that encapsulate and hence provide protection for the viral RNA or DNA. Caspar and Klug used this fact in their seminal work in 1962 to predict the numbers, types and relative orientations of the protein clusters in the capsids. However, predictions on the three-dimensional structure of individual capsid proteins and the packaged genomic material are inaccessible with their approach. We introduce here a new symmetry principle based on affine extensions of the icosahedral group that accounts for the radial distribution of all material boundaries in simple RNA viruses. These results show that the structure of the protein container of a virus and that of the packaged RNA are collectively constrained by symmetry, and that symmetry is hence more important for virus architecture than previously appreciated. As an application of these results, models for virus assembly are discussed. (Received August 26, 2008)

1046-92-326 **Eva M Strawbridge*** (emstrawbridge@math.ucdavis.edu), Department of Mathematics, One Shields Ave., Davis, CA 95616. *The Mechanics and Dynamics of DNA as an Elastic Rod.*

DNA is a sequence of bases strung together into strands, winding around each other. If the strands are pulled apart, the molecule overtwists in one direction, and undertwists in the other, causing it to warp. In DNA this is called supercoiling. We model the progression of supercoiling in the wake of the cellular machinery, motivated by the possibility that it may induce changes in cellular activity or structure. We consider a single molecule as a symmetric, linearly elastic rod. This is a fully dynamic approach. We treat our model in a rigorous form, with a careful consideration of a non-local drag force, when appropriate, and a rigorous treatment of the scaling relationships between the drag model and the equations of motion. We show that when drag is neglected, the planar rod possesses an unstable twist equilibrium. When this equilibrium is perturbed, the rod buckles into an unstable helical shape or experiences a variety of wave motions. Intuition leads us to believe that when drag is included, the twist propagation would subsequently loose all wave-like behavior resulting in the build-up of local twist quickly, in a small domain. (Received August 26, 2008)

1046-92-344 **Olli Ilari Tahvonen*** (olli.tahvonen@metla.fi), Finnish Forest Research Institute, PL 18 Vantaa, Finland. *Economics of harvesting age-structured fish populations.*

A generic discrete time age-structured fishery model is developed to derive analytical results for economically optimal harvesting. Given two age classes, knife-edge selectivity zero harvesting cost (or schooling fishery), the steady state is proved to be a unique saddle point. Adding harvesting cost does not alter the uniqueness given utility is linear. When fishing gear is nonselective, optimal harvesting may converge toward a stationary cycle that represents pulse fishing. Optimal steady states are shown to be different if age-structured information is ignored and optimization is based on biomass variables. This implies that optimal extinction results depend on age-structured information. Given a low rate of interest and knife-edge selectivity, optimal harvesting is shown to converge toward a unique saddle point independently of the number of age classes. (Received August 27, 2008)

1046-92-357 **Holly D. Gaff*** (hgaff@odu.edu), 3133A Health Sciences Blg, Community and Environmental Health, Old Dominion University, Norfolk, VA 23518, and **Elsa Schaefer** (elsa.schaefer@marymount.edu). *Metapopulation models in tick-borne disease transmission modeling.*

Human monocytic ehrlichiosis (HME) is a tick-transmitted disease with growing impact in the USA. Risk of a tick-borne disease to humans can be estimated using the prevalence of that disease in the tick population. A deterministic model for HME is explored to investigate the underlying dynamics of prevalence in tick populations. The dynamics in a single spatial patch are considered first to determine which model components are most important to predicting disease dynamics in a local ecology. The model is then expanded to spatially-explicit patches on which patch connectivity, the surrounding environment, and boundary effects are studied. The results of this investigation show that predicting risk of this disease to humans is determined by many complicated interactions. Areas that would be endemic in isolation may or may not sustain the disease depending on the surrounding habitat. Similarly, control efforts are shown to be far more effective when applied in wooded habitats than in neighboring grassy habitats. Boundary assumptions which describe the reality of increasing habitat fragmentation additionally play a large role in predicting the endemicity of an HME outbreak. Overall, HME and all tick-borne diseases are complex, nonlinear systems that have just begun to be explored. (Received August 27, 2008)

1046-92-389 **Robert J Ronkese*** (bob.ronkese@usma.edu), Dept . of Mathematical Sciences, United States Military Academy., West Point, NY 10996. *The Analysis of a Nonlinear Adaptive Elastic Plate Under Loading with Numerical Simulations of Its Displacement and Growth Under Various Boundary Conditions.*

Authors: Robert P. Gilbert (U. of Delaware) and Robert J. Ronkese (United States Military Academy, West Point, NY)

Presenter: Robert J. Ronkese (United States Military Academy, West Point, NY)

The plate and the rod are two geometric solids that can be used to model the trabeculae of bone. Trabucho and Viaño in 1996 and Figueiredo and Trabucho in 2004 have used the adaptive elastic rod to model the deposition and reabsorption (remodeling) of trabecular bone. In their models, the stress-strain relationship and a remodeling rate equation are both linear in terms of the strain tensor. Recently, Gilbert and Ronkese have extended this to formulate a model that includes the adaptive elastic plate in which the remodeling rate equation is quadratic with respect to the strain tensor. Numerical simulations of the displacement of this plate under loading as well as simulations of bone growth according to the remodeling rate equation will be shown for two original sets of boundary conditions and for intermediate cases, too. Background analysis of the model will be given beforehand as well. (Received August 29, 2008)

1046-92-417 **Zhongzhao Teng*** (zzteng@wpi.edu), Mathematical Sciences Department, Worcester Politechnic Institute, 100 Institute Road, Stratton Hall 108, worcester, MA 01609, **Xueying Huang** (xueying@wpi.edu), Mathematical Sciences Department, Worcester Polytechnic Institute, 100 Institute Road, Stratton Hall 108, worcester, MA 01609, **Zijie Liao** (zliao@wpi.edu), Mathematical Sciences Department, Worcester Polytechnic Institute, 100 Institute Road, Stratton Hall 108, worcester, MA 01609, and **Dalin Tang** (dtang@wpi.edu), Mathematical Sciences Department, Worcester Polytechnic Institute, 100 Institute Road, Stratton Hall 108, worcester, MA 01609. *Study on Critical Stress in Atherosclerotic Carotid Artery Using In Vivo MRI-Based 3D Multi-Physics Models with Fluid-Structure Interactions.*

Atherosclerotic carotid plaque might rupture without warning causing fatal events. Currently, plaque vulnerability assessment is based mainly on medical images and experience from physicians. However, both morphological information and mechanical forces should be considered in an integrated way for a better diagnosis. MRI-based computational models with fluid-structure interactions for human atherosclerotic carotid plaques were developed to perform mechanical analysis and quantify critical stress conditions related to plaque rupture. A critical site selection method to quantify critical stress was proposed. In vivo MR-images from 6 patients (3 ruptured plaques with ulcer and hemorrhage, 3 non-ruptured) were used. Proper circumferential and axial shrinking was performed to get the start shape for the numerical model. Results indicated that critical stresses from plaques with ulcer were significantly higher than the non-ruptured ones. Large scale patient-specific studies are needed for further validation of our method and findings. Acknowledgement: This research was supported by NSF grant DMS-0540684 and NIH grant R01 EB004759. MRI data was provided by Dr. Chun Yuan's group in University of Washington. (Received September 01, 2008)

1046-92-434 **Sebastian J. Schreiber*** (sschreiber@ucdavis.edu), Department of Evolution and Ecology, One Shields Avenue, University of California, Davis, CA 95616. *Should I stay or should I go? On the evolution of dispersal.*

Plants and animals often live in landscapes where environmental conditions vary from patch to patch and moment to moment. Since the fecundity and survivorship of an individual depends on these factors, an organism may decrease or increase its fitness by dispersing across the environment. Consequently, a fundamental question in evolutionary ecology is "how do dispersal patterns evolve in spatially and temporally heterogeneity environments?" To address this question, analytical results will be presented about periodically forced models of competing species that only differ in their dispersal strategies. The analysis combines standard techniques from monotone maps with new results about one-parameter families of non-negative matrices. Several challenging problems in dynamical systems and matrix analysis will be posed. This work is in collaboration with Chi-Kwong Li (College of William and Mary) and Steve Kirkland (University of Regina) (Received September 02, 2008)

1046-92-438 **Anita T Layton*** (alayton@math.duke.edu), Department of Mathematics, Duke University, Box 90320, Durham, NC 27708. *Tubuloglomerular Feedback Signal Transduction in a Compliant Thick Ascending Limb.*

We previously used a mathematical model of the thick ascending limb (TAL) to investigate nonlinearities in the tubuloglomerular feedback (TGF) loop. That model, which represents the TAL as a rigid tube, predicts that TGF signal transduction by the TAL is a generator of nonlinearities: if a sinusoidal oscillation is added to constant intratubular fluid flow, the time required for an element of tubular fluid to traverse the TAL, as a function of time, is oscillatory but nonsinusoidal. As a consequence, NaCl concentration in tubular fluid alongside the macula densa will be nonsinusoidal and thus contain harmonics of the original sinusoidal frequency. To address the concern that a more realistic model of the TAL would damp the harmonics, we have conducted new studies in a model TAL that has compliant walls and thus a tubular radius that depends on transmural pressure. These studies predict that compliant TAL walls do not damp, but instead intensify, the harmonics. In mathematical models, the impact of these harmonics on TGF-regulated SNGFR depends on the model formulation of the TGF response. We show by means of examples from the literature that the transmission of harmonics in TAL tubular fluid NaCl concentration to SNGFR depends critically on model assumptions. (Received September 02, 2008)

1046-92-469 **Daniel Maxin*** (daniel.maxin@valpo.edu), Valparaiso, IN 46383. *A gender structured model with single-biased separation rate.* Preliminary report.

We propose a two-sex demographic model with a modified divorce rate that reflects the correlation between single population size and the likelihood of couple separation. In the classical two-sex exponential model, we found that the single population pressure on the married couples alters the dynamics of the total population and causes the existence of an interior steady state. A Hopf bifurcation analysis around the interior equilibrium shows that, for a suitable divorce function, the model exhibits sustained oscillations. (Received September 04, 2008)

1046-92-485 **Suzanne Lenhart*** (lenhart@math.utk.edu), University of Tennessee, Math Dept, Knoxville, TN 37996-1300. *Spatial Optimal Control in Fishery Models.*

We consider optimal fishery harvesting problems for partial differential equation models. We discuss the time dependent and time independent cases, which correspond to parabolic and elliptic models respectively. The issue of marine reserves will be presented for several objective functionals. This includes joint work with Wandi Ding, Hem Raj Joshi, Ta Herrera and Mike Neubert. (Received September 04, 2008)

1046-92-502 **Shandelle M. Henson*** (henson@andrews.edu), Department of Mathematics, Andrews University, Berrien Springs, MI 49104, and **James L. Hayward** (hayward@andrews.edu), Biology Department, Andrews University, Berrien Springs, MI 49104. *Modeling "stay/flee" conflict situations in animal behavior: Poisson regression and differential equations.* Preliminary report.

Compartmental DEs can be used to model the incidence of animal behavior; inflows and outflows correspond to initiations and cessations of behavior. If the probability distribution of a random variable Y with mean r belongs to a certain class of distributions, then r can be transformed by a "link function" and regressed on environmental covariates. Such regression models are called "generalized linear models", or GLMs. If r is the mean number of events (e.g., behavior changes) per "person-hour" or per "individual-time" from a Poisson process, then r can be expressed as a function of environmental covariates using Poisson regression and incorporated into the DE model. If the log-transformed per capita rates of change in a DE model depend linearly on an environmental stimulus x that intensifies uniformly in time, then the behavioral dynamics predicted by the DE can display threshold-type events in which the probability of behavioral change is nearly zero for some time but suddenly shifts to one as the environmental stimulus becomes sufficiently strong. We illustrate with a "stay/flee" conflict situation in which gulls continue to guard their territories as an eagle approaches but suddenly flee as the predator draws sufficiently near. (Received September 05, 2008)

1046-92-505 **Horst R. Thieme*** (thieme@math.asu.edu), Department of Mathematics and Statistics, Arizona State University, Tempe, AZ 85287-1804, and **Thanate Dhirasakdanon**. *The persistence of ranavirus in salamanders with ephemeral larval habitats.* Preliminary report.

Salamander larvae in Arizona are only present during parts of the year, while terrestrial (adult) salamanders typical are too dispersed to allow frequent disease transmission. We test by a mathematical model the intraspecific reservoir hypothesis (Brunner et al., 2004) that ranavirus persists in Arizona salamander populations through yearly reintroduction of the virus into larval population by breeding adults.

Reference

Brunner, J.L., D.M. Schock, E.W. Davidson, J.P. Collins, Intraspecific reservoirs: complex life history and the persistence of a lethal ranavirus, Ecology 85 (2004), 560-566 (Received September 05, 2008)

1046-92-509 **David L Chopp*** (chopp@northwestern.edu), ESAM, Tech Institute, Northwestern University, 2145 Sheridan Rd., Evanston, IL 60208. *A Multi-Species Model for Bacterial Biofilms used in Waste Water Treatment.*

Bacterial biofilms are one of the most ubiquitous forms of life on the planet. Biofilms are aggregations of bacteria or other microorganisms that form on solid surfaces. Biofilms have a significant impact on human life, both negatively and positively. Biofilms are responsible for contributing to human disease, e.g. Legionnaires Disease, fouling pipes in food processing, and corroding ship hulls to name a few. On the other hand, biofilms can also be used to improve agricultural production, help make household cleaning products, and even produce electricity. In this talk we will focus on bacterial biofilms used in the reclamation of waste water where it is used to remove nitrates and nitrites from the fluid to produce nitrogen gas. We will discuss the issues related to improving performance of these biofilms in commercial reactors and how mathematical modeling is used to analyze the biofilms and their response to the environment in ways that cannot be done experimentally. (Received September 05, 2008)

1046-92-510 **J M Cushing*** (cushing@math.arizona.edu), Department of Mathematics, 617 N Santa Rita, University of Arizona, Tucson, AZ 85721, and **Rosalyn Rael**, **Thomas L Vincent** and **R F Costantino**. *Evolutionary reversals in competitive interactions: experimental occurrences and model explanations using Darwinian dynamics.* Preliminary report.

I will briefly describe two exceptional occurrences of evolutionary adaptation observed in laboratory experiments involving two competing species of insects (flour beetles of the genus Tribolium. The adaptive changes in these experiments resulted in two types of reversals in the expected outcome of the competitive interaction: (1) from competitive exclusion (i.e., one species goes extinct) to competitive coexistence and (2) from the exclusion of one species to the survival of that species and the exclusion of the other species. To investigate these possibilities theoretically, we consider an evolutionary game theoretic (EGT) extension of the classic Leslie-Gower (discrete Lotka-Volterra) competition model. We show that this standard competition model can predict scenario (1) only if a "boxer effect" is present (i.e., maximal competitive intensity does not occur when the species are identical), but even then the evolutionary trait (strategy) is not an evolutionary stable strategy (ESS). We also show that scenario (2) can occur in the model, but only if one of the species (and not both) undergoes evolutionary adaptation. (Received September 10, 2008)

1046-92-518 **Ian Besse*** (ibesse@math.uiowa.edu), Department of Mathematics, 15 Maclean Hall, University of Iowa, Iowa City, IA 52242, and **Colleen Mitchell** and **Erwin Shibata**. *A modified Mitchell-Schaeffer model of cardiac action potential which incorporates caveolae-associated ionic currents.* Preliminary report.

The contraction of a cardiac cell is initiated by a transient depolarization of the cell membrane called an action potential. Action potentials result from the rapid flux of ions across the membrane through voltage-dependent ion channels. Recent electrophysiological data regarding caveolae, microdomains on the subsarcolemma, reveal that caveolae are reservoirs of 'recruitable' ion channels. As such, caveolar ion channels constitute a substantial and previously unrecognized source of ionic currents that can significantly influence action potential morphology. We formulate and analyze a new model of cardiac action potential based on the incorporation of these caveolae-associated currents into the existing Mitchell-Schaeffer two-current model. This new model reproduces emerging experimental data on the function of caveolae and suggests that some cardiac arrhythmias might arise from caveolae-related biophysical mechanisms. (Received September 16, 2008)

1046-92-554 **Azmy S Ackleh*** (ackleh@louisiana.edu), 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** (qxh6207@louisiana.edu), Department of Mathematics, University of Louisiana at Lafayette, Lafayette, 70504-1010. *Deterministic and stochastic juvenile-adult models with application to amphibians.*

We present a deterministic juveniles-adult model where juveniles are structured by age and adults are structured by size. As is the case for many amphibian populations, we assume that juveniles (tadpoles) compete for different resources than adults (frogs). An explicit finite difference method to approximate the model solution is developed. Convergence of this method to the unique weak solution of the model is discussed. A discrete stochastic model based on the deterministic finite difference method is developed taking into account the inherent randomness in birth, death and age/size changes. As the time, age and size mesh lengths are decreased a system of stochastic partial differential equations (SPDE) is derived. Numerical results comparing the deterministic model solution to the mean of the discrete stochastic model and the mean of the SPDE solutions are presented. (Received September 07, 2008)

1046-92-614 **Howard Weiss*** (weiss@math.gatech.edu), School of Mathematics, Georgia Tech, Atlanta, GA 30334. *Fish Biomass Structure at Pristine Coral Reefs and Degradation by Fishing.* Preliminary report.

Apex predators constitute 85% of the total biomass at the pristine Kingman coral reef. This is in sharp contrast to most reefs where the prey biomass substantially dominates the total biomass. As pristine reefs like Kingman are thought to provide an important baseline for the natural state of coral reefs, an understanding of the biomass structure at pristine reefs is vital to reef restoration and conservation efforts.

Based on recent field observations, we model the biomass structure within the framework of an extended consumer-resource theory and provide a mechanistic explanation for the inverted biomass pyramid. As corals play a vital role in the ecology at reefs by providing a refuge for small prey from apex predators [14], the prey death rate and predator growth rate in our model are strongly dependent on the 'refuge size'.

Coral reef ecosystems around the world are under threat from overfishing. We show that suciently high fishing pressure will destroy the inverted biomass pyramid found at pristine coral reefs.

This is joint work with Georgia Tech colleagues Wendy Morrison (Biology), Abhinav Singh (Physics), and Hao Wang (Math). (Received September 09, 2008)

1046-92-625 **Amy J Ekanayake*** (a.drew@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79415-1042, and **Linda J.S. Allen**. *A comparison of the distributions of two stochastic models for metapopulation models.*

Approximately 25,000 playa lakes dot the Southern High Plains (SHP) of the United States. As the region's primary hydrological feature, playa lakes are crucial to the survival of SHP wildlife and migratory waterfowl. To model a SHP population, we consider playas as patches in Levins' metapopulation model and an extension of this model that includes patch destruction developed by Keymer and colleagues. To include variability in patch colonization, extinction, and destruction we formulate two stochastic models based on Levins and Keymer models: a continuous time Markov chain (CTMC) model and an Itô stochastic differential equation (SDE) model. Differential equations are derived for the moments of the distribution for both stochastic models. These equations are not closed; their solution depends on higher-order moments. We state cases for which the CTMC and SDE models have the same mean and variance for moment closure assumptions. Then we consider specific moment closure techniques based on normal and log-normal assumptions. Using these, we numerically solve for the mean, variance, skewness and kurtosis of the distributions. Additionally, many CTMC and SDE sample paths are generated from which the mean, variance, skewness and kurtosis are computed directly from the models. (Received September 09, 2008)

1046-92-714 **Miranda Ijang Teboh-Ewungkem*** (tebohewm@lafayette.edu), 225A Pardee Hall, Department of Mathematics, Lafayette College, Easton, PA 18042. *Mathematical Model to Quantify the Impact of the Recovery Rate on the Dynamics and Transmission of Malaria in a Changing Population: Case of Cameroon.*

Despite efforts to combat malaria, the disease remains a serious public health risk in the African regions where it is endemic. A susceptible, exposed and Infectious (SEI) differential equation model is developed and used to explore the behavior of the disease with variable host (human) and vector (mosquito) populations based on data from Cameroon. With a base set of parameters, the basic reproductive number, R0 is computed and the model realistically reproduces endemic stable infectious steady states and realistically shows that R0 is high when the

recovery rate is low. Moreover, with all other parameters held fixed, increasing the recovery rate reduces both the numerical values of the stable infectious steady states and R0. At a realistically high recovery rate value, a reduction in the contact rate between mosquitoes and humans leads to a greater impact of reducing the maximum infectious human populations and the time it takes for the disease free equilibrium to reach stability. Hence local communities can greatly impact the control and eradication of malaria by completing their treatment and seeking help as soon as they realize that they have malaria. Further, the use of bed nets needs reinforcement to help reduce contacts between mosquitoes and humans. (Received September 16, 2008)

1046-92-821 **Lynelle M Weldon** (weldon@andrews.edu), Department of Mathematics, Andrews University, Berrien Springs, MI 49104, **Shandelle M Henson**, Department of Mathematics, Andrews University, Berrien Springs, MI 49104, **James L Hayward**, Biology Department, Andrews University, Berrien Springs, MI 49104, **Libby C Megna*** (megna@andrews.edu), Biology Department, Andrews University, Berrien Springs, MI 49104, and **Joseph G Galusha**, Department of Biological Sciences, Walla Walla University, Walla Walla, WA 99324. *Effect of the Abiotic Environment on Preening in Glaucous-winged Gulls (Larus glaucescens), Part I.*

Preening is an important avian behavior that has been associated with maintenance of flight feathers, thermoregulation, parasite removal, stress reduction, and social interaction. We used logistic regression with information-theoretic techniques to study the incidence of preening in glaucous-winged gulls (Larus glaucescens) as a function of six environmental correlates and the stage of breeding season. We used the Akaike Information Criterion adjusted for overdispersion (QAIC) to select the best model from a suite of alternatives. From model averaged parameter estimates we estimated odds ratios with 95% confidence intervals (incorporating model uncertainty) for the effects of humidity, temperature, solar elevation, wind speed, tide height, and barometric pressure on the occurrence of preening. We summed Akaike weights to rank the factors in relative importance. The most important environmental correlates were temperature and humidity during the Nest-building/Egg-laying stage of the breeding season; solar elevation and tide height during the Egg-laying/Incubation stage; and barometric pressure, humidity, wind speed, and tide height during the Incubation/Chick-rearing stage. Overall, the most important factor in this suite of models was the stage of breeding season. (Received September 11, 2008)

1046-92-823 **Lynelle M Weldon*** (weldon@andrews.edu), Department of Mathematics, Andrews University, Berrien Springs, MI 49104, and **Shandelle M Henson**, **James L Hayward**, **Libby C Megna** and **Joseph G Galusha**. *Effect of the Abiotic Environment on Preening in Glaucous-winged Gulls (Larus glaucescens), Part II.*

Preening is an important avian behavior that has been associated with maintenance of flight feathers, thermoregulation, parasite removal, stress reduction, and social interaction. We used logistic regression with information-theoretic techniques to study the incidence of preening in glaucous-winged gulls (Larus glaucescens) as a function of six environmental correlates and the stage of breeding season. We used the Akaike Information Criterion adjusted for overdispersion (QAIC) to select the best model from a suite of alternatives. From model averaged parameter estimates we estimated odds ratios with 95% confidence intervals (incorporating model uncertainty) for the effects of humidity, temperature, solar elevation, wind speed, tide height, and barometric pressure on the occurrence of preening. We summed Akaike weights to rank the factors in relative importance. The most important environmental correlates were temperature and humidity during the Nest-building/Egg-laying stage of the breeding season; solar elevation and tide height during the Egg-laying/Incubation stage; and barometric pressure, humidity, wind speed, and tide height during the Incubation/Chick-rearing stage. Overall, the most important factor in this suite of models was the stage of breeding season. (Received September 11, 2008)

1046-92-890 **James F. Selgrade*** (selgrade@math.ncsu.edu), Box 8205, North Carolina State University, Raleigh, NC 27695-8205, and **Jordan West Bostic** and **James H. Roberds**. *Attractors for a periodic, discrete selection-migration model with partial dominance.* Preliminary report.

To study periodic immigration of genes into a natural population, a selection-migration model with density-dependent regulation is used to track allele frequency and population size over discrete generations. Conditions are found which guarantee the existence of a global attractor under the assumption of partial dominance in heterozygote fitness. Bounds for the variation in allele frequency for solutions within the attractor are determined and rates at which solutions approach the attractor are approximated. How the position of the attractor changes as the dominance parameter changes is studied. A measure of allelic diversity is introduced. (Received September 12, 2008)

1046-92-919 **Hannah L Callender*** (hannah.callender@gmail.com), IMA, 400 Lind Hall, 207 Church St SE, Minneapolis, MN 55408, and **Hans G Othmer**. *A Model of Cellular Motility: Focusing on the "Feet" of the Cell.*

Cell motility is an essential process in the life cycle of many organisms, as it plays a crucial role in a variety of areas such as embryonic development, wound healing, the immune response, and cancer cell metastasis. Furthermore, errors during cell migration have serious consequences including mental retardation, vascular disease, tumor formation, and metastasis. Therefore, an understanding of the mechanism by which cells migrate may lead to the development of novel therapeutic strategies for controlling, for example, invasive tumor cells.

Cells adhere to and move across their surroundings via protein complexes known as "focal adhesions" (FAs). FAs serve both as mechanical links from the cell to its surroundings (acting in some ways as cellular feet) and as biochemical signaling hubs to concentrate and direct numerous signaling proteins within the cell. Here we present a mathematical model to describe the early dynamics of these focal adhesions in mammalian cells to determine the necessary components and the role of each in the growth and fate of the FAs. (Received September 12, 2008)

1046-92-1053 **Joan P. Lubben*** (s-jlubben1@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, 203 Avery Hall, Lincoln, NE 68588-0130, and **Brigitte Tenhumberg** and **Richard Rebarber**. *The effect of temperature on transient population dynamics: A case study using the pea aphid (Acyrthosiphon pisum).* Preliminary report.

Studies of structured population dynamics often focus on asymptotic population growth rates, which assume that the population has reached the stable stage distribution. For many populations this assumption is not justified and the population is better described by short term or transient dynamics. Transient dynamics can be important for estimating invasion speed of non-indigenous species, population establishment after releasing biocontrol agents, or population management after a disturbance like fire. For ecothermal species like insects, temperature plays an important role in their developmental rate. We developed two different models to explore the effect of temperature on the transient population growth rate, using pea aphids as a case study. We estimated model parameters (survivorship and fecundity) at two different temperatures, and then scrutinized both model predictions by comparing observed and predicted transient population growth rates and the projection of population size over 20 days. We defined "transient amplification" and explored how temperature influences the transient amplification in this system. Both models predict that an increasing temperature produces earlier and higher peak transient growth rates, resulting in a larger transient amplification. (Received September 14, 2008)

1046-92-1079 **Andrew Gillette*** (agillette@math.utexas.edu), Department of Mathematics, 1 University Station C1200, Austin, TX 78712, and **Chandrajit Bajaj** (bajaj@cs.utexas.edu). *Applications of the Hodge Decomposition to Biological Structure and Function Modeling.* Preliminary report.

The Helmholtz decomposition ensures that a sufficiently smooth vector field can be written uniquely as the sum of a curl-free component, a divergence-free component and a harmonic component. The Hodge decomposition generalizes this result to differential forms and relates closely to solutions of Poisson's equation over the underlying space. Recent work has examined how these decompositions relate to singularities of vector fields for various types of flow. In this preliminary report, we will discuss why these results are relevant to biological structure and function modeling, especially in the context of electromagnetic forces between molecules. (Received September 16, 2008)

1046-92-1080 **Chandrajit Bajaj*** (bajaj@cs.utexas.edu), Department of Computer Sciences, 1 University Station C0200, Austin, TX 78712, and **Guoliang Xu** (xuguo@lsec.cc.ac.cn) and **Qin Zhang** (zqyork@ices.utexas.edu). *Molecular Solvation Models and Minimal Surfaces.*

Molecular surfaces of proteins and other biomolecules are often modeled as smooth analytic interfaces separating the molecule from solvent (an implicit solvation model). These analytic solvation models are often of high genus with a myriad of interconnected tunnels and pockets with openings (mouths). All these interfaces are biochemically significant as pockets are often active sites for ligand binding or enzymatic reactions and tunnels are often solvent ion conductance zones. In this talk, we present a general characterization of these solvation interfaces and approximately model them as piecewise minimal surfaces, namely, the solution of non-linear elliptic or biharmonic partial differential Euler-Lagrange equations obtained from the minimization of high-order energy functionals. This is joint work with members of my research group, in particular Guoliang Xu and Qin Zhang. (Received September 15, 2008)

1046-92-1100 **Tilahun Abay Muche*** (tmuche@mail.usf.edu), 4202 E. Fowler Avenue, PHY 114, Tampa, FL 33620. *Circular splicing language and maximal prefix code.* Preliminary report.

Splicing systems are generative devices of formal language, introduced by Head in 1987 to model biological phenomenon on linear and circular DNA molecules. In this paper I will restrict my self to the relationship between maximal prefix codes, circular splicing languages and circular regular languages. I will consider a class of regular languages along with a classes of language closed under conjugacy relation and with X a regular languages. (Received September 14, 2008)

1046-92-1145 **Sana Raoof*** (sraoof@fas.harvard.edu), 2178 Kirby Lane, Muttontown, NY 11791. *Computation of the Alexander-Conway Polynomial on the Chord Diagrams of Singular Knots.*

The inherent complexity of ambient isotopies, as outlined by the Reidemeister moves, necessitate the use of knot invariants to discriminate among planar representations of mathematical knots. The concept of finite-type invariants reduces the computation of the Alexander-Conway polynomial to the level of combinatorial objects called chord diagrams.

In this paper, we prove some relations for the /delta invariant, which is the formal logarithm of the Alexander-Conway polynomial.

A specific family of chord diagrams, denoted Sk,m, contains two disjoint sets of chords arranged in a lattice pattern. Sk,m chord diagrams are characterized by complete bipartite intersection graphs. This paper shows that /delta(Sk,m) = 0 for k not equal to m m!(m − 1)! for k = m The theorems presented in this paper increase our knowledge of the Alexander-Conway invariant for chord diagrams, as well as prove when the invariant can be accurately used to discriminate between knots. These findings pertain to the identification of tangled organic molecules such as DNA and RNA, and are applicable to the Protein Folding Problem. (Received September 14, 2008)

1046-92-1215 **Abdul-Aziz Yakubu*** (ayakubu@howard.edu), Department of Mathematics, Howard University, Washington, DC 20059, and **Michael Fogarty** (mfogarty@whsun1.wh.whoi.edu), North East Fisheries Science Center, National Marine Fisheries Service, Woods Hole, MA 02543. *Periodic Versus Constant Harvesting Of Discretely Reproducing Fish Populations.*

We use a single-species discrete-time model to demonstrate changes that introduction of the strong Allee mechanism and periodic exploitations have on compensatory and overcompensatory stock dynamics through comparison with corresponding models that lack such constraints. Periodic and constant exploitations simplify complex overcompensatory stock dynamics with or without the Allee effect. Both constant and periodic exploitations force a sudden collapse to extinction of fisheries systems that exhibit the Allee mechanism. However, in the absence of the Allee effect, fisheries systems decline to zero smoothly under high exploitation. (Received September 15, 2008)

1046-92-1269 **M Wilhelm*** (mewilhel@uncg.edu), 20031 Mulberry Street, Cornelius, NC 28031, and **J Rychtar**, **O Rueppell** and **M Chhetri**. *The Mating Game: A Game Theoretic Analysis of the Mating Sign Behavior in the Honeybee.*

The honeybee, Apis mellifera, exhibits extreme polyandry. After insemination, the male (drone) plugs the queen's genital opening with his endophallus, known as the mating sign. This leads to his immediate death and has been shown to promote additional mating of the queen, casting doubt on the adaptiveness of this behavior: the drone forgoes the chance of future mating and effectively dilutes his genetic contribution to the next generation. On the other hand, the mating sign may be beneficial because it increases the genetic variability of the queen's offspring and greater genetic variability increases colony fitness. With the analysis of this phenomena in mind, we constructed a game theoretic model in order to describe this situation. Using this model, the evolutionary stability of the drone's choice "to plug" or "not to plug" was investigated. Finally, we conclude that the drone's behavior is not adaptive based on data obtained from recent studies. (Received September 15, 2008)

1046-92-1335 **Kai-Bin Fu*** (kaibin@tamu.edu), Department of Mathematics, TAMU 3368, Texas A&M University, College Station, TX 77843. *The modeling of retinal ganglion cell (RGC) axons and its convexity properties.* Preliminary report.

Glaucoma is a group of diseases that can lead to damage of the eye's optic nerve and loss of vision. Most of these diseases are characterized by increased fluid pressure inside the eye. When the pressure increases, the retinal ganglion cell (RGC) axons are deformed, leading to the death of RGC axons which eventually results in the loss of vision.

We will present a model to examine the elongation of RGC axons. The analysis is based on the steady state theory for simple fluid which is in the literature. We obtained the velocity distribution of axons movement as well as the pressure distribution which is consistent with clinical experience. With the help of experimental data, we propose the constitutive relation for RGC axons.

We have also examined some mathematical features, namely convexity properties, of existing constitutive relation, for example the classical Fung model. We discuss the corresponding implications for the constitutive modeling. (Received September 15, 2008)

1046-92-1338 **Jordan West Bostic*** (kjwest@ncsu.edu), Department of Mathematics, North Carolina State University, Campus Box 8205, Raleigh, NC 27695, and **James H Roberds** and **James F Selgrade**. *Dynamical behavior of a one-island, selection-migration model with partial dominance.* Preliminary report.

Selection and migration influence the genetic makeup and demographics of a population. A one-island model is studied, in which the island population receives immigrants from a continent population. Density-dependent selection takes place within the island population and then population migration occurs. A two-dimensional system of nonlinear difference equations describes the change in allele frequency and population density over generations for this model. A polymorphic equilibrium exists under biologically reasonable conditions for the case of partial dominance in fitness. Conditions on the degree of dominance and the frequency of the gene migrating into the continental population are necessary to show uniqueness and stability of the equilibrium. Some results on the existence and location of attractors are discussed. As genetically engineered crops become more prevalent, the one-island model may be useful for understanding the effects of transgenic invasion on gene frequency in natural populations. (Received September 16, 2008)

1046-92-1421 **Tatiana Valerievna Tatarinova*** (ttatarin@lmu.edu), Department of Mathematics, Loyola Marymount University, Los Angeles, CA 90045, and **Alan Schumitzky** (schum@usc.edu), Department of Mathematics, USC, Los Angeles, CA 90089. *Kullback-Leibler Markov Chain Monte Carlo – a new Algorithm for Finite Mixture Aanalysis and its Application to Gene Expression Data.*

A number of methods have been developed for clustering gene expression data. We would like to suggest a new Bayesian method for clustering of data-rich time-series observations. Experimental points of the time series observations are ordered and this fact sets them apart from other microarray measurements. In this paper we study Bayesian analysis of nonlinear hierarchical mixture models with a finite but unknown number of components. Our approach is based on Monte Carlo Markov Chain (MCMC) methods. One of the applications of our method is directed to the clustering problem in gene expression analysis. From a mathematical and statistical point of view, we discuss the following topics: Theoretical and practical convergence problems of the MCMC method; Determination of the number of components in the mixture; Computational problems associated with likelihood calculations. In the existing literature, these problems have mainly been addressed in the linear case. One of the main contributions of this paper is developing a method for the nonlinear case. Our approach is based on a combination of methods including Gibbs sampling, Random Permutation sampling, Birth-Death MCMC, and Kullback-Leibler distance. (Received September 15, 2008)

1046-92-1428 **Channa N Navaratna*** (channa@iup.edu), Department of Mathematics, 210 South 10th Street, Indiana, PA 15705, and **Menaka B Navaratna** (mnavarat@fgcu.edu), Department of Physical Sciences and Mathemati, 10501 FGCU Boulevard South, Fort Myers, FL 33965. *Radio-telemetry under malfunctioning receivers.*

Radio-telemetry is an excellent tool for gathering data on the biology of freely moving animals. Transmitters small enough to fit on the backs of birds or be clipped onto small animals are being heavily used by scientists to identify behavioral patterns of animals. Directional antennas are commonly used in tracking freely moving animals with tags. Physical limitations of antennas and different environmental conditions interfere the receivers and may deviate recordings received from the signal transmitter. In addition, with intermittent radio signaling, one can not expect that all receivers are positioned in a location to receive the same signal at the time it is being transmitted. Contrary to the mathematical models that estimate the location of free-ranging animals using the reception of transmitted signal by all receivers our method can also be applied in absence of some receivers. The main methodology we utilized in our model is Monte Carlo methods in conjunction behavioral patterns of wildlife in order to improve estimates. The model will continually update its predictions using the available measurements. Simulation experiments are carried out to show the effectiveness of these filters in locating animals with tracking devices. (Received September 15, 2008)

1046-92-1486 **David J Gerberry*** (gerberry@math.purdue.edu), Department of Mathematics, 150 N. University Street, West Lafayette, IN 47907. *Bifurcations in an SEIQR Model for Childhood Diseases.*

Explaining the recurrent outbreaks of childhood diseases has long been a topic of discussion in the modeling community. Initial explanations concluded that stochastic and/or seasonal forces gave rise to sustained oscillations. Feng and Thieme showed that deterministic factors alone could lead to periodic solutions.

In this work, we extend the model of Feng and Thieme to include a latent class. We are able to prove the existence of supercritical Hopf bifurcations and hence sustained oscillations. Through this extension, we are able to gain more insight into the behavior of solutions in three-dimensional parameter space. We are also able to prove the existence of homoclinic bifurcation in a biologically feasible unfolding of a simplified version of our model. (Received September 15, 2008)

1046-92-1551 **Tamara E Awerbuch-Friedlander*** (Tamara@hsph.harvard.edu), Harvard School of Public Health, 665 Huntington ave, Boston, MA 02115. *"Trends and oscillations in the dynamics of linear vs. non-linear difference equation models describing populations".* Preliminary report.

Population dynamics of organisms with various developmental stages is complex in nature. Emerging populations can be described by a system of non-bounded delayed equations. The mathematical analysis of a linear model describing tick populations, resulted in a cubic characteristic equations, with three eigenvalues characterizing the pattern of growth; one dominant determining the main trend and two others, adding riding oscillations. Superimposed, we also found oscillations due to fluctuating environments which strongly affect the magnitude of these eigenvalues (Awerbuch and Sandberg 1995).However to account for long-term density dependence effects, the model was modified to capture seasonal transitions of the three developmental stages, with population regulation represented by an exponential inhibition of growth of one of the stages (Awerbuch-Friedlander, Levins, and Predescu. 2005); this resulted in a delay difference equation of order two:

$y(n+1)=A*y(n-1)*\exp(-y(n-1))+ B*y(n)$

The analysis of the model revealed parameter regions of oscillatory behavior, the source being the non-linear component of the model. (Received September 16, 2008)

1046-92-1584 **Ryusuke Kon*** (kon-r@bio-math10.biology.kyushu-u.ac.jp), Hakozaki 6-10-1, Higashi-ku, Fukuoka, 812-8581, Japan. *Dynamics of a discrete-time lottery model and its approximation by ODEs.* Preliminary report.

Temporal heterogeneity is one of the important factors promoting species coexistence. The lottery model proposed by Chesson and Warner (1981) plays an important role in understanding the role of temporal heterogeneity. In this talk, we derive an ODE model from the original discrete-time lottery model by mean of averaging and analyze it since ODE models are often mathematically more tractable than discrete-time models. In fact, the mathematical framework of competitive exclusion constructed by McGehee and Armstring (1977) and the Liapunov function constructed by Kubo and Iwasa (1996) are applicable to our ODE model. These applications help to understand the global dynamics of the original discrete-time lottery model and show how to count the number of resources generated by temporal heterogeneity. (Received September 16, 2008)

1046-92-1668 **Christopher C Leary*** (leary@geneseo.edu), Department of Mathematics, SUNY Geneseo, 1 College Circle, Geneseo, NY 14454. *Average Distance and the Cantor Set.*

When investigating fractal and fractal-like images, mathematicians and biologists have tried to quantify various aspects of the image. The fractal dimension has (in some sense) been used to measure how much space an object occupies. In an effort to quantify the manner in which that space is occupied, various measures have been proposed, including lacunarity and the nearest neighbor distance. We suggest that computing the average distance between points in the set might be a more useful measure and compute the average distance between points in the Cantor set and several of its variants. (Received September 16, 2008)

1046-92-1701 **Joseph Briggs** (jsbriggs@ncsu.edu), **Kathryn Dabbs*** (kdabbs1@utk.edu) and **Daniel Riser-Espinoza** (drisere1@swarthmore.edu). *An Integral Projection Model Analysis for an Endangered Plant.*

We use an integral projection model (IPM) to analyze the population dynamics of blowout penstemon *(Penstemon haydenii).* In Nebraska this endangered plant naturally occurs in "blowouts", which are sparsely vegetated depressions in active sand dunes created by wind erosion. We estimate size dependent survival, growth, and fecundity, and density dependent recruitment probability from a large data set spanning 13 blowout sites in western Nebraska. For this model, there is an asymptotic population and stage structure, which is independent of the nonzero initial population and stage structure; this is observed numerically and can be proved mathematically. We also analyze the transient dynamics that are predicted if the population deviates from the stable stage distribution. Our model predicts that in the early phase of blowout colonization population density drops to very small numbers before increasing to the asymptotic population size ("transient dip"). This suggests a very small colonization success of this plant since small populations have a high extinction risk because of demographic and environmental stochasticity and Allee effects. We use robustness analysis to evaluate different management strategies. (Received September 16, 2008)

1046-92-1717 **Kasey Crompton** (kc_2001_nicole@hotmail.com), Columbia, SC 29208, **Andrew Davis** (davisad@clarkson.edu), Postsdam, NY 13699, **Satoru Ito*** (sito@ncsu.edu), Raleigh, NC 27695, **Amanda Olsen** (amolsen@lagrange.edu), LaGrange, GA 30240, **Gregory Morton** (gregory1morton@gmail.com), Atlanta, GA 30314, **Daniela Valdez** (dvaldez@ncsu.edu), Raleigh, NC 27695, and **Mette Olufsen** (msolufse@ncsu.edu), Raleigh, NC 27695. *Predicting viscoelastic properties of the arterial wall.*

This study utilizes a 2-parameter elastic model and a 4-parameter Kelvin viscoelastic model to predict elastic and viscoelastic properties of the arterial wall using in-vivo measurements of vessel area and blood pressure. Data were measured in the proximal ascending aorta in seven sheep at a number of different frequencies. Mechanical properties were predicted by solving the inverse problem minimizing the least squares error between computed and measured values of vessel area. Results showed that we were able to estimate model parameters using only a portion of the data. While the vessel radius was not significantly impacted by changes in frequency, differences were observed in both elastic and viscoelastic parameters. Results of sensitivity analysis showed that all parameters were sensitive, and since all model parameters are independent, we conclude that it is possible to estimate all parameters. Moreover, results showed that the Kelvin viscoelastic model was able to capture the pressure-area hysteresis, which the elastic model could not predict. Finally, we showed that the hysteresis is significantly smaller in-vivo than in-vitro, a phenomenon, which may be a result of smooth muscle cell regulation and support of adventitia. (Received September 16, 2008)

1046-92-1718 **Jeremy J. Thibodeaux*** (jthibodeaux@ucok.edu), University of Central Oklahoma, Mathematics Department, 100 N. University Dr., Edmond, OK 73034. *A Mathematical Model of Erythropoiesis Subject to Malaria Infection.*

There have been numerous mathematical studies on the dynamics of erythropoiesis. The same can be said of the dynamics of malaria infection within a particular host. In this study, we develop a mathematical model of erythropoiesis under the influence of malaria infection. The model takes the form of six coupled equations. Two are first-order, hyberbolic, partial differential equations describing the precursor and mature erythrocyte populations. The remaining four are ordinary differential equations describing the erythrpoietin concentration, the parasite population, the infected erythrocyte population, and the body's immune response. (Received September 16, 2008)

1046-92-1726 **Deena M Hannoun*** (hannoudm@jmu.edu), 1726 Three Springs Rd., McGaheysville, VA 22840, and **Joseph Schutte**, **Anthony Tongen** and **Corey Cleland**. *A Mathematical Model for the Nociceptive Withdrawal Response of Rats.*

In this project, we elicit a nociceptive withdrawal response from a rat through experimental means. The rat's response is captured by two perpendicular high-speed video cameras. We then use a direct linear transformation to transform the video data into three-dimensional global coordinates. The transformed data is used to create a three-dimensional trajectory of the nociceptive withdrawal response and determine the direction of the response with respect to the rat's coordinate system. After determining this trajectory, we use Newton's Law to fit a coupled system of ten ordinary differential equations that describe spring and mass motion to the tail's motion by adjusting the system's parameters. The goal of this project is to use the coupled system of ordinary differential equations to predict the direction of the rat's nociceptive withdrawal response and to determine the forces generated by the tail during the nociceptive withdrawal response. (Received September 16, 2008)

1046-92-1728 **Harold M Hastings*** (harold.hastings@hofstra.edu), CHPHB 102, 151 Hofstra University, Hempstead, NY 11549-1510, and **Bruce S Schneider**, Office of Cellular, Tissue and Gene Therapies, Center for Biologics Evaluation and Research, Food and Drug Administration, Rockville, MD 20852. *Statistical Geometry of Pancreatic Islets.*

We report on an experimental study which found that the spatial distribution of islets in the guinea pig pancreas has correlation dimension 1.5 in 2D sections, thus correlation dimension 2.5 in the 3D pancreas, up to an outer scale of 3 mm. Since many mammalian islets are innervated, and since Caserta showed that the growth of neuronal branching processes follows a diffusion limited aggregation (which has correlation dimension 2.5 in

3D), these results suggest a role for neuronal growth factors in islet formation. The findings and conclusions in this presentation have not been formally disseminated by the Food and Drug Administration and should not be construed to represent any Agency determination or policy. (Received September 16, 2008)

1046-92-1757 **Jan Rychtar*** (rychtar@uncg.edu), Department of Mathematics and Statistics, UNCG, Greensboro, NC 27402, and **Mark Broom**, Department of Mathematics, University of Sussex, Brighton, England. *Mathematical models of kleptoparasiting behavior.*

Kleptoparasitism is the stealing of food by one animal from another. This has been modeled in various ways before, but all previous models have only allowed contests between two individuals. We design and analyze a model of kleptoparasitism where individuals are allowed to fight in groups of more than two, as often occurs in real populations. We find the equilibrium distribution of the population amongst various behavioral states, conditional upon the strategies played and environmental parameters, and then find evolutionarily stable challenging strategies. We find that there is always at least one evolutionary stable strategy, but sometimes there are two or more, and discuss the circumstances when particular ESSs occur, and when there are likely to be multiple ESSs. (Received September 16, 2008)

1046-92-1815 **Daniel L Kern*** (kernd@unlv.nevada.edu), Dept of Mathematical Sciences/UNLV, 4505 Maryland Parkway, Box 454020, Las Vegas, NV 89154-4020. *Optimal Control Model for Cancer Chemotherapy Subject to Drug Resistance.*

Optimal control techniques are used to optimize a chemotherapy treatment regime. Cell cycle-specific chemotherapy is examined when drug resistance reduces the effectiveness of treatment over time, and toxicity levels place limitations on the course of treatment. The resulting treatment level thus needs to balance multiple factors.

The governing state equations are developed for a four-compartment model indicating the development of resistance over time, resulting in a coupled system of nonlinear differential equations. The optimal control is characterized for the problem through the Hamiltonian and the adjoint system. This allows for some numerical simulations using a iterative forward-backward sweep in time. (Received September 17, 2008)

1046-92-1847 **D Brian Walton*** (waltondb@jmu.edu), MSC 1911, Roop 110, James Madison University, Harrisonburg, VA 22807, and **Anthony Tongen**, **Phillip Andreae**, **Adam Falk**, **Sarah Mecholsky** and **Theresa Klinkhammer**. *Exploring Male Dimorphism in the Dung Beetle using a Discrete-time Stochastic Population Model.* Preliminary report.

Certain dung beetles exhibit a male dimorphism wherein some males will develop horns and then use a defensive mating behavior while other males will not develop a horn and then uses a sneaking mating behavior. The decision for whether the male develops a horn or not is based on whether the male reaches a critical threshold during development. The level of this threshold is inherited. The probability of a male in the next generation inheriting the threshold depends on the number of matings the female has with males of each type. Sneak males have a smaller chance of successful matings but a higher per-encounter potency. Guard males have a higher chance of successful mating. We develop a probabilistic model for the probability that an egg will be fertilized by a given type given the number of males of each type in the current generation. Using the ideas of adaptive dynamics as applied to difference equations, we develop analogous results for the long-term success of a given threshold. We identify an optimal threshold level that establishes the ideal balance between guard and sneak males. (Received September 16, 2008)

1046-92-1896 **Frederick A. Adkins*** (fadkins@iup.edu), 212 Stright Hall, Mathematics Department, Indiana, PA 15705. *Modeling MicroRNA Targets via Clustering of mRNA Microarray Data.* Preliminary report.

MicroRNA (miRNA) affect gene expression by either blocking translation or cleaving target mRNA resulting in subsequent degradation. This study investigates models for the role of miRNA in gene expression. Modeling provides a mechanism for possible discovery of new miRNAs and identification of miRNA targets in conjunction with mRNA expression levels. Gene expression mRNA and miRNA data for various disease states are clustered to identify genes that are significantly up or down regulated. For significantly down regulated genes, computational methods are used to identify possible common complementary 20-26 nucleotide sequences that are characteristic of microRNA. Based on weighted sequence alignment, free energy at the target site, and other factors that characterize miRNA, likelihood models can be built to determine likely miRNA and their targets. This method of miRNA target investigation attempts to utilize clustering of levels for gene expression to predict common miRNA targets. Correlation of known miRNA hairpins or computational investigation of possible pri-miRNA hairpins to correspondingly up-regulated mRNA from microarray clustering analysis is used to create models useful for exploration of regulatory networks reflecting cellular activity. (Received September 16, 2008)

1046-92-1934 **Carlos Castillo-Chavez*** (ccchavez@asu.edu), PO BOX 871904, Tempe, AZ 85287-1904, **Eunok Jung** (eunokjung@gmail.com), 1 Hwayang-dong, Gwangjin-gu, Seoul, 143-701 South Korea, Seoul, South Korea, and **Sunmi Lee** (mathever@gmail.com), 1 Hwayang-dong, Gwangjin-gu, Seoul, 143-701 South Korea, South Korea. *On the Dynamics and Control of Drinking: The Role of Control Theory in Combating Relapse and Other Factors.*

A simple mathematical model is used to model the dynamics of drinking in homogeneous mixing communities. The role of relapse, social and the identification of optimal approaches to reduce drinking are explored. (Received September 16, 2008)

1046-92-1940 **J. S. Kimbell*** (kimbell@thehamner.org), The Hamner Institutes for Health Sciences, P.O. Box 12137, Res. Triangle Park, NC 27709, and **J. D. Schroeter** and **G. J. M. Garcia**. *Mathematical Modeling in Nasal Drug Delivery and Surgery.* Preliminary report.

Millions of people are affected each year in the US by nasal symptoms that require therapeutic drugs or surgical intervention. The nasal passages, due to their rich vascularization, also represent an opportunity for the systemic delivery of pharmaceuticals. Innovative approaches are needed to optimize nasal drug delivery by maximizing drug deposition at sites of interest, minimizing side effects, and reducing waste of expensive compounds. Recently, three-dimensional (3D) mathematical models of the nasal passages have been used to study nasal deposition of sprayed and nebulized drug particles as well as the potential effects of surgery on nasal function. A preliminary study was conducted to estimate a particle size range for optimal nebulized particle deposition in four normal people and one surgery patient. Preliminary results indicate that nebulized particles between 7 and 15 microns in aerodynamic diameter are likely to optimize nasal drug delivery for systemic action. The 3D models are also being explored as a strategy to improve the outcome of nasal surgery through virtual surgical planning. These studies demonstrate the significant value that mathematical modeling can have in the real world of innovation in medicine. (Received September 16, 2008)

1046-92-1942 **Carlos Castillo-Chavez*** (ccchavez@asu.edu), PO BOX 871904, Tempe, AZ 85287-1904, **Karen Rios-Soto** (karen_rs@math.uprm.edu), Departamento de Matematics and Statistics, Mayaguez, PR , and **Kailash Patidar** (Kailash.Patidar@asu.edu), PO BOX 871904, Tempe, AZ 85287-1904. *Models of Disease Dispersal for populations with overlapping and non-overlapping discrete populations.* Preliminary report.

The spatial spread of epidemics in populations with discrete generations is modeled using integro-difference equations. The existence of traveling epidemic wave solutions in growing and non-growing populations is studied in the context of overlapping and non-overlapping generations of infectious individuals. (Received September 16, 2008)

1046-92-1947 **Nikolay S Strigul*** (nstrigul@stevens.edu), Department of Mathematical Sciences, Stevens Institute of Technology, Castle Point on Hudson, Hoboken, NJ 07030. *On the forest transient dynamics in the Perfect Plasticity Approximation model.* Preliminary report.

Recently we have developed tractable macroscopic equations for forest dynamics, the so called perfect plasticity approximation, PPA (Strigul et al., 2008, Ecological monographs). This mathematical model is a system of hyperbolic partial differential equations coupled with an additional integral equation (the PPA equation). Most of our analytical results presented in the initial paper concerned stationary regimes including stability analysis and invasion and coexistence in the stationary state. While the stationary regimes are analytically tractable, the transient dynamics presents a significant challenge. Here we will present recent results concerning transient dynamics of tree monocultures; in particular, we have obtained a closed analytical solution for the transient period before the moment of canopy closure. Currently we work to generalize this solution for the case of a multiple species model, which should provide better understanding of tree coexistence and forest succession. (Received September 16, 2008)

1046-92-1968 **Chang Hyeong Lee*** (changlee@wpi.edu), 100 Institute Road, Department of Mathematical Sciences, WPI, Worcester, MA 01609. *A multi-time-scale analysis of biochemical reaction networks.*

We consider deterministic and stochastic descriptions of biochemical reaction networks in which various reactions occur on two or more time scales. In the deterministic description, we obtain an explicit form of a reduced equation on a slow time scale by applying a singular perturbation method to the full governing equation. We derive a necessary and sufficient condition under which there is a complete separation of slow and fast variables and explore topological properties which guarantee that the condition is satisfied. In the stochastic description, we obtain a reduced form of the governing equation, so-called the chemical master equation, by applying a state space decomposition method to the full governing equation. Based on the analytic result, we approximate reaction probabilities and implement an efficient stochastic simulation algorithm in the slow time scale. We illustrate the numerical efficiency and accuracy of the reduction method by simulating deterministic and stochastic models of several interesting biological examples. (Received September 16, 2008)

1046-92-1995 **Sheree L. Arpin*** (sarpin@frc.mass.edu), Department of Mathematics, 100 State Street, Framingham State College, Framingham, MA 01701-9101, and **J. M. Cushing**, Department of Mathematics, 617 N Santa Rita, University of Arizona, Tucson, AZ 85721. *Modeling frequency-dependent selection in a population of fish.*

We present a discrete-time model for a population of predatory cichlid fish known to exhibit frequency-dependent selection. We construct the model by incorporating both population genetic and population dynamic processes. We show the model predicts a temporal phenotypic oscillation in mouth-handedness, which coincides with field data and is driven by the defense mechanism of the prey species. Furthermore, our analysis indicates a previously unknown and, perhaps, unexpected feature of the oscillation. We will discuss the different routes to destabilizing a 1:1 phenotypic ratio and their biological implications. (Received September 16, 2008)

1046-92-2026 **Giulio Genovese*** (giulio.genovese@dartmouth.edu), 6188 Kemeny Hall, Hanover, NH 03755. *Extracting information from genotype data of closely related individuals.* Preliminary report.

Extracting information from dense genotype data to discover regions shared between relatives is a powerful technique to discover genes that give predispositions to a given disease. The problem offers different computational and statistical challenges from the modeling of errors of genotype data to the combinatorial analysis of the pedigree describing the relationship among the individuals that have been genotyped. Different algorithms have been developed, some of which are though impractical since their running time grows exponentially in the size of the pedigree of the individuals. A new algorithm, approximate but robust, is described. The idea behind the algorithm is to loose some of the constraints and perform a sort of gradient descent to extract statistical information in a practical way. (Received September 16, 2008)

1046-92-2098 **Mahbubur M Rahman***, Mahbubur Rahman, Department of Mathematics & Statistics, 1 UNF Drive, University of North Florida, Jacksonville, FL 32224. *Horizontal Gene Transfer of Kinetic Network in Aquifer media.* Preliminary report.

We costruct a mathematical model using conventional model of gene transfer, which can uncover the kinetics of horizontal gene transfer and its effects on the environment. (Received September 17, 2008)

1046-92-2114 **Yangjin Kim*** (ykim@mbi.osu.edu), Mathematical Biosciences Institute, OSU, Jennings Hall, 3rd Floor, 1735 Neil Avenue, Columbus, OH 43210, **Avner Friedman** (afriedman@math.ohio-state.edu), Mathematical Biosciences Institute, OSU, Jennings Hall, 3rd Floor, 1735 Neil Avenue, Columbus, OH 43210, **Julie Wallace** (Julie.Wallace@osumc.edu), Human Cancer Genetics, OSU, 810 Biomedical Research Tower, 460 W. 12th Ave., Columbus, OH 43210, **Fu Li** (Fu.Li@osumc.edu), Human Cancer Genetics, OSU, 810 Biomedical Research Tower, 460 W. 12th Ave., Columbus, OH 43210, and **Michael Ostrowski** (michael.ostrowski@osu.edu), Human Cancer Genetics, OSU, 810 Biomedical Research Tower, 460 W. 12th Ave., Columbus, OH 43210. *Interaction of tumor with its microenvironment : A mathematical model.*

In order to understand the role of fibroblasts and myofibroblasts in the early induction of breast cancer in vitro, we developed a mathematical model to simulate interactions between these fibroblasts and tumor epithelial cells as well as performed experiments to validate the model. The mathematical model describes the dynamics of various concentrations of cells and growth factors present in the tumor microenvironment by a system of differential equations. In the experiments, tumor cells are placed on one side of a membrane and either normal fibroblasts or tumor associated fibroblasts are placed on the other side. This membrane is semi-permeable, allowing growth factors such as EGF and TGF-β to cross over, however restricting cells from being in direct contact with each other. Simulation of our mathematical model and results from our experiments were in good agreement and therefore confirmed the models ability to predict aspects of tumor cell behavior in response to signaling from fibroblasts. (Received September 17, 2008)

1046-92-2130 **Amit Singer*** (amits@math.princeton.edu), Princeton University, Department of Mathematics & PACM, Fine Hall, Washington Road, Princeton, NJ 08544-1000. *Structure Determination through Eigenvectors of Sparse Operators*

In many applications, the main goal is to obtain a global low dimensional representation of the data, given some local noisy geometric constraints. In this talk we will show how the problems listed below can be efficiently solved by constructing suitable operators on their data and computing a few eigen- vectors of sparse matrices corresponding to the data operators.

Cryo Electron Microscopy for protein structuring: reconstructing the three-dimensional structure of a molecule from projection images taken at random unknown orientations (unlike classical tomography, where orientations are known).

NMR spectroscopy for protein structuring: finding the global positioning of all hydrogen atoms in a molecule from their local distances. Distances between neighboring hydrogen atoms are estimated from the spectral lines corresponding to the short ranged spin-spin interaction.

Sensor networks: finding the global positioning from noisy local distances.

Joint work with Ronald Coifman, Yoel Shkolnisky (Yale Applied Math) and Fred Sigworth (Yale School of Medicine). (Received September 29, 2008)

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1046-93-285 **N. U Ahmed*** (ahmed@site.uottawa.ca), SITE, 161 Louis Pasteur, University of Ottawa, Ottawa, Ontario K1N6N5, Canada. *Kalman Filtering of Measure Driven Processes in Hilbert Space.*

Let $\{X, Y, U, V\}$ be separable Hilbert spaces on which are defined the following system of stochastic evolution equations,

$$dx = Axdt + B(t)x(t-)\nu(dt) + \sigma(t)dW(t), x(0) = x_0, t \geq 0, \tag{1}$$

$$dy = H(t)x(t-)\beta(dt) + \sigma_0(t)M(dt), y(0) = 0, t \geq 0, \tag{2}$$

where A generates a C_0 semigroup on X and $\{B, \sigma, H, \sigma_0\}$ are operator valued functions and $\{\nu, \beta\}$ are countably additive signed measures. The processes $\{W, M\}$ are U and V valued Brownian motion and Martingale measures on a filtered probability space $(\Omega, \mathcal{F}, \mathcal{F}_{t\geq 0}, \mathcal{F}_t^y, P)$ with covariance operators Q and $R\tilde{\beta}(dt)$, $\tilde{\beta}$ a positive measure. Problem is: Find the best estimate of $x(t)$ given the history $\mathcal{F}_t^y$ which is given by $\hat{x}(t) = E\{x(t)|\mathcal{F}_t^y\}$. This is equivalent to the control problem: Find $\Gamma \in B_\infty(I, \mathcal{L}(Y, X))$ that minimizes the error covariance functional $J(\Gamma) = \int Tr(\lambda(t)K(t))dt$ with K satisfying the evolution equation

$$\begin{aligned} dK &= (AK + KA^*)dt + (BK + KB^*)\nu(dt) + \hat{Q}(t)dt \\ &\quad -(\Gamma HK + KH^*\Gamma^*)\beta(dt) + (\Gamma\hat{R}\Gamma^*)\tilde{\beta}(dt), t \geq 0, \end{aligned} \tag{3}$$

on the Banach algebra $\mathcal{L}(X)$. (Received August 25, 2008)

1046-93-452 **Gheorghe Morosanu*** (morosanug@ceu.hu), Department of Mathematics, Nador u. 9, Budapest, 1051, Hungary. *Input Identification to Linear Differential Systems.*

Consider in a given finite interval (0,T) the linear time-invariant system dx/dt=Ax+Bu, y=Hx, where A, B, H are given matrices, x=x(t) denotes the state of the system, u=u(t) is a control policy (input), and y=y(t) is the output trajectory.

A necessary and sufficient condition for input identification to linear differential systems of the above form is given. Our result is based on a finite iterative process and its proof uses elementary arguments involving matrices, finite dimensional linear spaces, Gronwall's lemma, linear differential systems. Our condition is equivalent to the classical condition involving the geometrical concept of controlled invariant. The dimension reduction algorithm we propose seems to be useful in designing deconvolution methods.

Some open problems are also discussed, including the case when A is a nonlinear monotone operator. (Received September 03, 2008)

1046-93-463 **Vu Ngoc Phat*** (vnphat@math.ac.vn), Department of Control and Optimization, Institute of Mathematics, 18 Hoang Quoc Viet, Cau Giay, Hanoi 10307, Vietnam. *Global stabilization of nonlinear switched time-delay systems via matrix inequalities.* Preliminary report.

This paper deals with the global stabilization for a class of nonlinear hybrid control systems with time-varying delay. Using Lyapunov-Razumikhin functional approach combined with Newton-Leibniz formula, neither restriction on the derivative of time-delay function nor bound restriction on nonlinear perturbations is required to design switching rule for exponential stabilization of nonlinear switched systems with time-varying delays. The conditions are presented in terms of the solution of some matrix inequality equations (Received September 03, 2008)

1046-93-961 **Gisele Massengo Mophou*** (gmophou@univ-ag.fr), Universite de Antilles et de Guyane, Campus de Fouillole, Pointe à Pitre, 97159 Pointe à Pitre, France, and **Ousseynou Nakoulima** (onakouli@univ-ag.fr), Universite des Antilles et de Guyane, Campus de Fouillole, Pointe à Pitre, 97122 Pointe à Pitre, France. *On a Method of Resolution of Controllability Problems for a Semilinear Heat Equation: Application to the Sentinels.*

We are interested in the control of the semilinear heat equation in order to subject its solution to constraints, here a finite number of linear constraints. It is a problem of the type controllability that we analyze in two steps. Firstly, we study the linearized problem, interpreting each linear constraint by the adjoint state. We show that the problem of control on the solution is equivalent to a problem of constraint on control. Then, using an inequality of observability which derives from the inequality of Carleman, we solve the equivalent problem. Secondly, we prove by means of a point-fixed argument that the results obtained for the linearized problem remain valid for semilinear case. We then applied the results obtained to the sentinels theory of J. L. Lions. (Received September 13, 2008)

1046-93-1160 **Laura Munteanu*** (Laura.Munteanu@oneonta.edu), 2 Circle Dr., Sidney, NY 13838. *A Distribution Approach to (Bi)Simulation Relations for Nonlinear Control Systems.* Preliminary report.

We explore certain aspects of the algorithm for computing the maximal (bi)simulation relation between two nonlinear control systems. More precisely, we use the theory of distributions along submanifolds to provide conditions ensuring that the algorithm works for a sufficiently large class of nonlinear control systems. (Received September 14, 2008)

1046-93-1307 **Gangaram S. Ladde*** (gladde@cas.usf.edu), Department of Mathematics and Statistics, University of South Florida, 4202 East Fowler Avenue, PHY 114, Tampa, FL 33620-5700. *HYBRID DYNAMIC INEQUALITIES UNDER RANDOM PERTURBATIONS AND APPLICATIONS.* Preliminary report.

In this work, a mathematical model for interconnected stochastic dynamic phenomenon evolving under different measure chains with state dependent discrete events is formulated. By introducing an arbitrary pair of functionals of a pair of flows, a composite system of dynamic inequalities with corresponding comparison hybrid dynamic system is outlined. The byproduct of this provides an estimate for these pair of functionals. Furthermore, by employing vector Lyapunov/energy like functions as functionals of hybrid dynamic flows, several results are developed. The obtained results extend and generalize the existing results in a systematic way. (Received September 15, 2008)

1046-93-1438 **Luis R Suazo*** (luisris@hotmail.com), 2003 bruce street, apartment 3, conway, AR 72034, and **Weijiu Liu**. *Controlling the Motion of Charged Particles in a Vacuum Electromagnetic Field from Boundary.*

We consider the problem of driving two non-relativistic charged particles in a bounded vacuum electromagnetic field to a same location by applying electromagnetic forces through the boundary of the domain. The dynamics of the particles is modeled by Maxwell's equations coupled with the Lorentz force law and the problem is reduced to a boundary feedback control problem. Using the perturbed energy method, we design feedback controllers and prove that the particles under the designed control move to the origin exponentially. Our result may have potential applications in particle acceleration and nuclear fusion. (Received September 15, 2008)

1046-93-2046 **Dinesh B Ekanayake*** (dinesh.ekanayake@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79415-1042, and **Ram V Iyer**. *Tracking control of nonlinear systems with uncertainties in the presence of hysteresis and saturation.*

Piezoelectric, magnetostrictive and shape memory alloy actuators are becoming increasingly important in high frequency and high precision applications, such as vibration control and precision positioning. However, due to the presence of nonlinear physical phenomena, including hysteresis and saturation, control of these actuators is extremely challenging at high frequencies. To study this issue, we consider a feedback control of a class of single-input single-output nonlinear systems in the presence of hysteresis with saturation. In the literature, it is assumed that systems undergo hysteresis only in the input channel and that hysteresis does not become saturated. We do not assume these limitations. We consider system of functional differential equations which includes hysteresis operators. We discuss a controller which forces the output of the system to follow a specified trajectory. We desire uniform ultimate boundedness in the presence of exogenous disturbances and uncertainty in the model. Most controllers use inverse compensators to cancel actuator hysteresis nonlinearity. We show that uniform ultimate bounded control can be achieved without an explicit inverse computation. (Received September 16, 2008)

94 ► Information and communication, circuits

1046-94-274 **Le Gui*** (gule@math.uiowa.edu), 14 MacLean Hall, the University of Iowa, Iowa City, IA 52242-1419. *Can You Hear Me Now?* Preliminary report.

In real life when we store and transmit analog audio or video signals, we first obtain a digital representation of the signal. This process is called Digitization or Analog-to-Digital (A/D) conversion. It consists of two steps: sampling and quantization. In the "sampling" step, we restrict time to a discrete sample of the continuous times. In the "quantization" step, we discrete the real values of the time-discrete sample of the first step. We will discuss different quantization methods based on binary expansion or Beta-expansion and compare their "accuracy." "Accuracy" means that we can re-construct a good approximation of the original signal from its digitization. (Received August 25, 2008)

1046-94-465 **Robert Calderbank*** (calderbk@math.princeton.edu), Applied and Computational Mathematics, Princeton University, Fine Hall, Room 206, Princeton, NJ 08540. *Golay, Heisenberg and Weyl.* Preliminary report.

Sixty years ago, efforts by Marcel Golay to improve the sensitivity of far infrared spectrometry led to the discovery of pairs of complementary sequences. We will describe how these sequences are finding new application in active sensing, where the challenge is how to see faster, to see more finely where necessary, and to see with greater sensitivity, by being more discriminating about how we look. (Received September 04, 2008)

1046-94-503 **Dima Grigoriev**, Institut de Recherche Mathématique, Campus de Beaulieu, 35042 Rennes, France, and **Vladimir Shpilrain*** (shpil@groups.sci.ccny.cuny.edu), The City College of New York, New York, NY 10031. *Authentication schemes.*

In the first part of the talk, we will describe a couple of general ways of constructing Feige-Fiat-Shamir-like authentication schemes from actions of a semigroup on a set, without exploiting any specific algebraic properties of the set acted upon. Then we will give several concrete realizations of this general idea, and in particular, describe several authentication schemes where both forgery (a.k.a. impersonation) and recovering the prover's long-term private key are NP-hard. Computationally hard problems that can be employed in these realizations include Graph Homomorphism, Graph Colorability, Diophantine Problem, and many others.

In the second part of the talk, we will describe an authentication scheme, based on an altogether different idea, where forgery is apparently infeasible without finding the prover's long-term private key. (Received September 05, 2008)

1046-94-685 **Mark F. Flanagan** (mark.flanagan@ieee.org), Winterthurerstrasse 190, CH-8057 Zurich, Switzerland, **Vitaly Skachek*** (vitaly.skachek@ucd.ie), CASL, Belfield, Dublin 4, Ireland, **Eimear Byrne** (ebyrne@ucd.ie), Belfield, Dublin 4, Ireland, and **Marcus Greferath** (marcus.greferath@ucd.ie), Belfield, Dublin 4, Ireland. *Polytope Representations for Linear-Programming Decoding of Nonbinary Linear Codes.*

The decoding of binary LDPC codes using linear-programming decoder was proposed by J. Feldman *et al.* The connections between linear-programming decoding and classical belief-propagation decoding were established in that paper. In our work, we extend the above approach to coded modulations, in particular to codes over rings mapped to nonbinary modulation signals. In both cases, the principal advantage of the linear-programming framework is its mathematical tractability.

For the binary coding framework, alternative polytope representations were studied, which give a complexity advantage in certain scenarios. In this work, we define two alternative polytope representations, which offer a smaller number of variables and constraints for many classes of nonbinary codes. These polytope representations, when used with the respective nonbinary LP problems, lead to polynomial-time decoders for a wide variety of classical nonbinary codes. (Received September 10, 2008)

1046-94-841 **Mark F. Flanagan*** (mark.flanagan@ieee.org), Department of Mathematics, University of Zurich, Winterthurerstrasse 190, CH-8057 Zurich, Switzerland, **Enrico Paolini** (e.paolini@unibo.it), DEIS, University of Bologna, via Venezia 52, 47023 Cesena (FC), Italy, **Marco Chiani** (marco.chiani@unibo.it), DEIS, University of Bologna, via Venezia 52, 47023 Cesena (FC), Italy, and **Marc P.C. Fossorier** (mfossorier@ieee.org), ETIS ENSEA / UCP / CNRS UMR-8051, 6, avenue du Ponceau, 95014 Cergy Pontoise, France. *On the Growth Rate of the Weight Distribution of Irregular Doubly-Generalized LDPC Codes.*

Low-density parity-check codes (LDPC codes) are a class of high-performance error correcting codes first introduced by Gallager in the 1960s. The asymptotic growth rate of the weight distribution of LDPC and related codes is a topic whose study dates all the way back to this early time in coding theory. In this talk, we derive an expression for the asymptotic growth rate of the number of small linear-weight codewords of irregular doubly-generalized LDPC (D-GLDPC) codes. The expression is compact and generalizes existing results for LDPC and generalized LDPC (GLDPC) codes. In the case where there exist check and variable nodes with minimum distance 2, it is shown that the growth rate depends only on these nodes, and the important parameter

$$\frac{1}{P^{-1}(1/C)}$$

is identified which discriminates between an exponentially small and an exponentially large expected number of small linear-weight codewords. An important connection between this new result and the stability condition of D-GLDPC codes over the BEC is highlighted. Such a connection, previously observed for LDPC and GLDPC codes, is now extended to the case of D-GLDPC codes. (Received September 12, 2008)

1046-94-854 **Felice Manganiello*** (felice.manganiello@math.uzh.ch), Mathematics Institute, Zurich University, Winterthurerstrasse 190, 8057 Zurich, Switzerland, and **Elisa Gorla** and **Joachim Rosenthal**. *On algebraic constructions of codes for random linear network coding.*

In 2007 Kötter and Kschischang introduced a new framework for random linear network coding. Messages are now encoded in vector spaces and transmitted over the channel via a basis representation. A new metric is also described which relates the distance between vector spaces to the dimension of their intersection. This new framework poses an interesting challenge: investigate possible algebraic constructions of codes of vector spaces.

Starting from the construction of spread codes obtained in collaboration with Elisa Gorla and Joachim Rosenthal, the talk will continue surveying new known constructions of codes over Grassmannians (viewed as collection of fixed dimension vector spaces).

References

[KK07] R. Koetter and F. Kschischang. Coding for errors and erasures in random network coding. arXiv.org:cs/0703061, 2007.

[MGR08] F. Manganiello, E. Gorla, and J. Rosenthal. Spread codes and spread decoding in network coding. In *Proceedings of the 2008 IEEE International Symposium on Information Theory*, pages 851–855, Toronto, Canada, 2008.

(Received September 12, 2008)

1046-94-1176 **DAE SAN KIM*** (dskim@sogang.ac.kr), Department of Mathematics, Sogang University, Seoul, 121-742, South Korea. *Infinite Families of Recursive Formulas Generating Power Moments of Kloosterman Sums: Symplectic Case.*

In this paper, we construct two infinite families of binary linear codes associated with double cosets with respect to certain maximal parabolic subgroup of the symplectic group $Sp(2n, q)$. Here q is a power of two. Then we obtain an infinite family of recursive formulas for the power moments of Kloosterman sums and those of 2-dimensional Kloosterman sums in terms of the frequencies of weights in the codes. 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 symplectic groups $Sp(2n, q)$. (Received September 15, 2008)

1046-94-1447 **Rainer Steinwandt*** (rsteinwa@fau.edu), Department of Mathematical Sciences, Florida Atlantic University, 777 Glades Road, Boca Raton, FL 33431. *Group Theory in Authenticated Key Establishment: What Assumption(s) Do We Make?*

When exploring the potential of group theory for constructing key establishment schemes, cryptographic issues like authentication and key derivation are not always discussed in detail. Conceptually, it seems desirable that addressing these questions does not impose the introduction of additional (possibly idealizing) assumptions.

The talk discusses techniques for (password-based) authentication and for key derivation in key establishment protocols. At this, the focus is on the so-called standard model, i.e., a scenario where no idealizing assumptions, like the availability of a random oracle, can be made. (Received September 15, 2008)

1046-94-1490 **Min Lu*** (lu_min@math.psu.edu), 404 McAllister Building, University Park, PA 16802. *Enumerating Pseudo-codewords in Fundamental Cones.*

The nature of the message passing decoding algorithm suggests that pseudo-codewords are critical in studying the performance of parity check codes. Koetter,Li,Vontobel and Walker showed in their paper that pseudo-codewords are the integer points congruent to codewords modulo 2 in the fundamental cone. In this paper it is shown that the generating function of the pseudo-codewords $\sum_{\mathbf{p}} \mathbf{x}^{\mathbf{p}}$ is rational. Besides the generating function some other rational functions recording pseudo-codewords are also given. To obtain the explicit form of these functions the structure, especially the generators, of the fundamental cones must be known. As such, the generators of fundamental cones are exhibited for some special parity check matrices. (Received September 15, 2008)

1046-94-1517 **Yesem Kurt*** (ykurt@randolphcollege.edu), 2500 Rivermont Ave, Randolph College, Lynchburg, VA 24503. *An Identification Scheme for One-Time Private Key Systems (OTPK).* Preliminary report.

One-Time Private Key (OTPK) is a new technology for online digital signatures in Public Key Infrastructure (PKI) architecture. In PKI a user chooses a private key, computes the public key,and sends it to the Trusted Authority (TA) for certification. Once he/she receives his certificate, he/she can sign messages using the private key. The certificate is valid until it expires typically for months. The idea in OTPK is to use a new private key and a new certificate each time a document is signed. It has several advantages over regular PKI. In this talk we shall describe a signature scheme which assumes that the private key is used only once (hence could be used in an OTPK system). The scheme works over non-commutative structures and relies on triple decomposition problem in the structure. (Received September 16, 2008)

1046-94-1540 **Eric Thomas Psota*** (epsota24@bigred.unl.edu), 329E Walter Scott Engineering Center, Lincoln, NE 68588. *Extrinsic Tree Decoding of LDPC Codes.*

Low density parity check (LDPC) codes are capable of exceptional performance when decoded with iterative message-passing decoders such as the sum-product (SP) and min-sum (MS) decoders. The behavior of these decoders is optimal on codes whose graphical representation (Tanner graph) is a given by a tree. Unfortunately, practical codes are seldom represented by a tree, and analysis is difficult when the Tanner graph contains cycles. In his thesis, Wiberg introduces the computation tree as a tool for modeling the SP and MS algorithm. While, in theory, this tool allows one to predict the performance at any given iteration, the size of the computation trees makes it impractical to analyze.

Here, we introduce a new decoding method called Extrinsic Tree (ET) decoding. This new decoder operates by building finite computation trees with a minimal number of copies of each variable node. This construction does not allow single channel errors to reinforce themselves and infect the rest of the graph. Another advantage of ET decoding is that performance can be bounded using the size and multiplicity of the deviation set. Lastly, it can be shown that ET decoding performance can be improved by manipulating the parity check matrix of the code in ways that SP/MS decoding can not. (Received September 15, 2008)

1046-94-1612 **Deanna Dreher*** (s-dturk1@math.unl.edu), 203 Avery Hall, Lincoln, NE 68588. *Trellis Pseudocodewords.*

Tail-biting trellises admit pseudocodewords in much the same way that Tanner graphs do, and questions that have been asked about graph cover pseudocodewords of Tanner graphs are also relevant in the case of trellis pseudocodewords. In this talk, we raise and answer some of these questions, including giving answers in the trellis situation to questions that are currently unanswered in the case of graph covers. (Received September 16, 2008)

1046-94-1796 **Robert Ghrist*** (ghrist@math.upenn.edu), 200 S. 33rd St., Philadelphia, PA 19104, and **Yuliy Baryshnikov**. *Topological sensing: doing more with less in sensor networks via topological data.*

One strategy for dealing with ever-increasing floods of data is to throw most of it away. The typical impulse in engineering and science is to perform expensive and data-intensive state estimation, with the goal of eliminating as much uncertainty as possible. This talk will argue for a minimalist approach, using small quantity or low-quality information to perform tasks robustly. The key mathematics tools are topological, in order to maintain robust, global features of data.

The general principle of minimalism will be specified in the context of sensor networks and data associated to spatially distributed systems. (Received September 16, 2008)

1046-94-1960 **Christine A Kelley*** (ckelley2@math.unl.edu), Department of Mathematics, 203 Avery Hall, University of Nebraska -Lincoln, Lincoln, NE 68506. *Further analysis of codes based on permutations.*

In this talk, we discuss some new results on codes designed from permutation voltage graphs. (Received September 16, 2008)

1046-94-2012 **Abigail G. Mitchell*** (abigail.mitchell@math.unizh.ch), Institute for Mathematics, University of Zuerich, Winterthurerstr. 190, CH-8057 Zuerich, Switzerland. *On right-regular graphs for cascaded LDPC codes.*

Luby, Shokrollahi and others have shown that random irregular graphs with particular degree sequences can be cascaded together to produce codes which achieve capacity on the binary erasure channel. Of these various degree sequences, the most strongly capacity-achieving is in fact a right-regular sequence. Recently we have introduced an explicit construction of such right-regular graphs; in this talk we examine the performance of this construction, particularly with regard to pseudocodeword weight. This is joint work with Joachim Rosenthal, also at the University of Zürich. (Received September 16, 2008)

1046-94-2067 **Olga V. Holtz*** (holtz@math.berkeley.edu), University of California, Department of Mathematics, 951 Evans Hall #3840, Berkeley, CA 94720. *Compressive sensing: a paradigm shift in signal processing.*

We survey a new paradigm in signal processing known as "compressive sensing". Contrary to old practices of data acquisition and reconstruction based on the Shannon-Nyquist sampling principle, the new theory shows that it is possible to reconstruct images or signals of scientific interest accurately and even exactly from a number of samples which is far smaller than the desired resolution of the image/signal, e.g., the number of pixels in the image. This new technique draws from results in several fields of mathematics, including algebra, optimization, probability theory, and harmonic analysis. We will discuss some of the key mathematical ideas behind compressive sensing, as well as its implications to other fields: numerical analysis, information theory, theoretical computer science, and engineering. (Received September 17, 2008)

97 ► Mathematics education

1046-97-25 **Ivo D. Dinov*** (dinov@stat.ucla.edu), SOCR Resource, UCLA Statistics, 8125 Math Sciences Bldg, Los Angeles, CA 90095, and **Nicolas Christou**. *Integrated, Multidisciplinary and Technology-Enhanced Science Education: The Next Frontier.*

Contemporary STEM education at all levels presents several critical pedagogical and social challenges to educators and learners alike. Among these challenges are the widening Intergenerational Information Technology divide and the need for a comprehensive and balanced multidisciplinary training. The Intergenerational IT divide reflects a different growing misalignment between providers and recipients of the science and technology educational content in terms of the expected vs. supplied, needed vs. perceived and contextual vs. abstract specialized learning. The transfer and blending of data, research challenges and methodologies between diverse areas of science is critical in motivating wider spectra of students, demonstrating cross-disciplinary methodological concepts and synergies, as well as for engaging students in research projects. This paper will illustrate a technology integrated approach to multidisciplinary STEM education and will suggest techniques for resolving these two challenges. (Received June 09, 2008)

1046-97-75 **Richard Millman** and **Eric L Clark*** (eclark@ms.uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40506. *Bluma's Method: A Different Way to Solve Quadratics.* Preliminary report.

In this talk, we introduce a different approach to finding the solutions of a quadratic equation and provide two proofs of its correctness. It involves transforming a given, arbitrary quadratic into one whose coefficient of the squared term is one and whose solutions are related easily to the solutions of the original. This is a technique that has been incorporated into middle and high school classrooms and has been a successful tool for professional development. We describe both the method and how to implement it in PD sessions and show how it can help develop a mathematical habit of the mind. (Received July 21, 2008)

1046-97-250 **Jana R. Talley***, 355 48th Ave NW #4, Norman, OK 73072. *Prior Knowledge and Calculus Performance.*

This study investigates the responses to prior knowledge errors that Calculus I instructors make when assessing students. A two part qualitative study consisting of student exams and instructor interviews was employed. Instructors of a summer Calculus I course were interviewed and asked to elaborate on exam grading decisions. Analysis of these interviews were used to develop additional interview questions for Calculus I instructors of various research and teaching backgrounds. (Received August 22, 2008)

1046-97-489 **Bret Benesh**, **Andrew Engelward** and **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**.
Inquiry-Based Learning Opportunities for Secondary Teachers and Students.

The Harvard University Extension School offers masters degree in mathematics for teaching. In addition, a large number of high school students participate Harvard's Secondary School Program taking college courses through the Harvard University Summer School. In this talk we will describe several inquiry-based learning courses for both secondary school teachers and students offered in these programs. (Received September 04, 2008)

1046-97-513 **Morton Brown*** (mbrown@umich.edu), Morton Brown, Department of Mathematics, University of Michigan, Ann Arbor, MI 48109. *Two very different Inquiry Based Learning courses at the University of Michigan.*

I will discuss two courses that have been given at University of Michigan: "Principles of Analysis" and "Mathematical Games". The first is a rigorous examination of the notions of convergence, limits, continuity and the real line. I will summarize the experiences of the instructors and students who have taught and taken the course over the last few years. The second course, Combinatorial Combat, has been successful with both high school and college students. Students play and study two person combinatorial games (finite, perfect information, with no "chance"). The goal is to is to utilize interesting and challenging mathematical games to introduce students to generic concepts of mathematical thinking not frequently found in beginning calculus courses: searching for patterns, thinking logically and systematically, problem solving, abstracting, choosing effective notation, and developing proofs. (Received September 05, 2008)

1046-97-553 **M. Padraig McLoughlin*** (mcloughl@kutztown.edu), 265 Lytle Hall, Department of Mathematics, Kutztown University of Pennsylvania, Kutztown, PA. *Incorporating Inquiry-Based Learning in the Calculus Sequence: A Most Challenging Endeavour.*

A course in the Calculus sequence is arguably the most difficult course in which inquiry-based learning (IBL) can be achieved with any degree of success within the curriculum in part due to 1) the plethora of majors taking Calculus to which the sequence relates to their majors in what is considered an 'applied' manner; 2) the sequence is intertwined such that 'coverage' matters since if a critical concept or area was not 'covered' in Calculus I or II it might do serious harm to the student in Calculus II or III where the understanding the topic may depend significantly on said material which was not 'covered.'

So, this paper argues (pedagogical and practical justification are submitted) for use of a modified Moore method (MMM) which employs elements of the classic Moore method (students doing rather than seeing, hearing, or reading) which creates a moderate pace for the course; not too fast (as perhaps in a traditional German seminar (recitation) method) nor too slow (as perhaps in a constructivist or pure Moore method course) and presents the model for use the MMM in the Calculus sequence. Further, it is proposed that the MMM assists students to establish a firm foundation for subsequent course work and creates the potential for maximal possibility to master the material. (Received September 09, 2008)

1046-97-594 **Rachel Cochran**, Center for Educational Accountability, **John Mayer*** (mayer@math.uab.edu), University of Alabama at Birmingham, Dept. of Mathematics, Birmingham, AL 35294-1170, and **Bernadette Mullins**, Birmingham Southern College.
Changing K-16 Classroom Practice. Preliminary report.

The University of Alabama at Birmingham, as part of the Greater Birmingham Mathematics Partnership, has instituted a program for teacher certification in mathematics at the middle school level which is the first of its kind in the state. UAB has also developed a new track in the mathematics major, Mathematical Reasoning, suitable for pre-service middle school mathematics teachers. This track includes newly developed courses as well as courses with revised content and pedagogical approach. This study focuses on the impact of the courses on pre-service teachers as well as changes in faculty classroom practice at the university level. (Received September 16, 2008)

1046-97-618 **Matthias K Gobbert*** (gobbert@math.umbc.edu), Department of Mathematics and Statistics, University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250, and **Nagaraj K Neerchal**, Department of Mathematics and Statistics, University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250. *Career Preparation of Mathematics and Statistics Students through Interdisciplinary Research and Consulting.*

In both academic and non-academic career paths, it is vital for Mathematicians and Statisticians to interact effectively with colleagues from other fields. To provide the opportunity to gain demonstrated experience with the necessary skills, the Department of Mathematics and Statistics at the University of Maryland, Baltimore County (UMBC) created the Center for Interdisciplinary Research and Consulting (CIRC). On the outside, CIRC makes the departmental expertise in our fields available to clients on and off campus through consulting services. On the inside, it provides an environment for our students to learn the art of being a professional Mathematician or Statistician by broadening subject-matter breadth, written and oral communication skills, entrepreneurial experience with marketing and promotion, and more. Graduate students from both of our programs in Applied Mathematics and in Statistics participate in CIRC by working as Research Assistants or by taking the course Introduction to Interdisciplinary Consulting, both supervised and supported at all times by the directors of CIRC. (Received September 09, 2008)

1046-97-627 **Michael Starbird*** (starbird@mail.utexas.edu), Department of Mathematics, The University of Texas at Austin, 1 University Station, C1200, Austin, TX 78712. *Guided Discovery: Teaching Mathematics/Transforming Lives.* 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. Guided discovery can be an important component of the education of students. (Received September 09, 2008)

1046-97-642 **Carol S Schumacher*** (schumacherc@kenyon.edu), Department of Mathematics, Kenyon College, Gambier, OH 43022. *Real Analysis—an inquiry-based approach.*

In an introductory real analysis course, students seriously confront the mathematics of limiting processes for the first time. This presents some conceptual challenges that are particular to analysis. In particular, reading, understanding and negating statements with stacked quantifiers; using analytical definitions involving quantifiers as "organizing principles" for planning and writing a proof; understanding the difference between proving a theorem in which a complicated sentence involving quantifiers is a conclusion and using such a sentence as a hypothesis in proving a theorem about something else. When teaching real analysis using an inquiry-based approach, we have the added challenge of helping our students confront and surmount these obstacles while leaving the proofs of the theorems to them. We will discuss specifically how to help students understand and use definitions from analysis, and how to help students make connections between heuristic ("closer and closer") language and the precise language of "epsilonics." If time permits, I will also talk about the connections between geometric and analytical ideas and how to get students using good pictures both for their own reasoning and to help in the presentation of analytical ideas. (Received September 09, 2008)

1046-97-644 **M. Padraig McLoughlin*** (mcloughl@kutztown.edu), 265 Lytle Hall, Dept. of Mathematics, Kutztown University of Pennsylvania, Kutztown, PA 19530. *Inquiry-Based Learning: An Educational Reform Based Upon Content-Centred Teaching.*

We posit that inquiry-based learning (IBL) enacted via a modified Moore method (MMM) is a content-driven pedagogy; as such it is content-centred not instructor- or student-centred. The MMM is a philosophy of education where student must master material by doing; not simply discussing, reading, or seeing it.

The pedagogy of IBL is like no other pedagogy (for others focus on manner of exposition, recitation, activities, exercises, etc. and less with the content as oft content is secondary to the method) because in IBL content is primary.

Many methods of instruction are not active but rather passive and some students wish to be passive and do the least (work) for the most (highest grade). IBL cannot be done passively. For a student to master material it is necessary for the instructor to be a master of the material so that the instructor may guide students through the content; hence, the IBL is in the tradition of a master-apprentice system.

The major focus of the paper is on how the use of the MMM creates a more effective mathematical education for students; how use of the MMM established an atmosphere that created for many students firm and authentic understanding of many of the principles of mathematics; and, therefore is key in mathematics education reform. (Received September 09, 2008)

1046-97-664 **Susan Elaine Thompson*** (sthompson@otterbein.edu), Mathematical Sciences Department, One Otterbein College, Westerville, OH 43081. *Comparing Methods of Instruction in Intermediate Algebra for College Students, Round 2.* Preliminary report.

Does the use of online content in teaching intermediate algebra to college students produce better results than a more traditional lecture approach? This investigation compares the learning of two groups of intermediate algebra students at a small, private, comprehensive institution with a college-wide mathematics requirement. One group will use MyMathLab, a text-specific online course that provides individual assessment and a variety of learning mechanisms, as the primary teaching/learning tool. Students will spend three days per week working individually in a computer laboratory with instructor supervision/assistance and two days per week in brief lecture and/or in groups determined by identified areas of weakness or strength. The second group will act as a control group, with traditional lecture (by the same instructor) five days per week as the primary teaching/learning tool. Data gathered will include a pre-test and a common final examination, among other things. Preliminary results will be shared at this session. (Received September 09, 2008)

1046-97-684 **Annie Selden*** (`aselden@math.nmsu.edu`), Dept. of Mathematical Sciences, New Mexico State University, Las Cruces, NY 88003-8001, and **John Selden** (`jselden@math.nmsu.edu`), Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88003-8001. *Habits of Mind for Proving.*

There are certain aspects of proving that mathematicians do automatically, but that students are often unaware of. We define the formal-rhetorical part of a proof to be those aspects of a proof that can be written by examining the logical structure of the statement of a theorem and by unpacking associated definitions. Examples include writing the first and last lines, unpacking the last line, considering what strategy one might invoke to prove it, and unpacking the hypotheses. Writing the formal-rhetorical part of a proof can expose "the real problem" to be solved. Students need to make doing such things automatic, that is, they must become habits of mind. Beginning students often fail to examine the conclusion; instead, they have a habit of beginning with the hypotheses and forging ahead rather blindly. This may come from high school geometry where this strategy may have served them well. This is a "bad habit" that needs to be replaced by the "good habit" of examining the conclusion. We will discuss this and other habits of mind that can be encouraged such as looking up definitions when one is unsure of what a term means – something students are often reluctant to do. (Received September 10, 2008)

1046-97-701 **Jonathan Rogness*** (`rogness@math.umn.edu`), Vincent Hall 4, 206 Church St SE, Minneapolis, MN 55455, and **Harvey B Keynes**. *Creating Regional Networks of Elementary and Middle School Teachers through Professional Development.*

We will describe unique aspects to our professional development programs for elementary and middle school teachers. Supported by a variety of MSP and ITQ grants, we focus on improving content knowledge of core topics in algebra and geometry, and especially the connections between these areas. Like many similar programs, the main component of our program is a two or three week summer course, but with key differences: (1) participants receive graduate credit in mathematics, not in education, (2) teachers come from many districts, and (3) teachers must attend events in our Academic Year Network to obtain a high grade. These events include opportunities to mentor students in their home schools, teach innovative Saturday morning enrichment classes to students in grades 4-7, attend seminars covering interesting mathematics outside of the regular school curriculum, and go to workshops addressing issues in mathematical knowledge for teaching. (Received September 10, 2008)

1046-97-728 **John D. Boller*** (`boller@math.uchicago.edu`), Univeristy of Chicago, Mathematics Department, 5734 S. University Ave., Chicago, IL 60637. *Upper-level undergraduate IBL mathematics classes at the University of Chicago.*

With three years of IBL offerings for first-year undergraduates under its belt, the University of Chicago Mathematics Department began offering upper-level IBL courses in the autumn of 2007. These courses comprised a year-long sequence in Analysis in $\mathbb{R}^n$ and have since been expanded to include a course in Basic Number Theory, a course in Basic Geometry, and a course in Topics in Algebra. The speaker will discuss the nature of these courses, including the recruitment of students, the development of course materials, faculty staffing requirements, and the evidence of success. (Received September 10, 2008)

1046-97-730 **Diane Herrmann*** (`diane@math.uchicago.edu`), University of Chicago, Mathematics Department, 5734 S. University Ave., Chicago, IL 60605. *IBL in Freshman Calculus at the University of Chicago.*

Since 2004, University of Chicago freshmen have had the option of taking Honors Calculus in an Inquiry Based Learning (IBL) format. The history of this option, including specifics about how the course is organized, what materials are used, how students are evaluated, and student performance in subsequent mathematics courses will be discussed. Exit interviews with students who started in IBL Honors Calculus in 2004 and graduated in 2008 will be shared. Ideas for involving faculty and graduate students in the project will be included. (Received September 10, 2008)

1046-97-742 **Sandra L. Laursen*** (sandra.laursen@colorado.edu), Ethnography & Evaluation Research, University of Colorado, 580 UCB, Boulder, CO 80309-0580, and **Marja-Liisa Hassi** (hassi@colorado.edu), Ethnography & Evaluation Research, University of Colorado, 580 UCB, Boulder, CO 80309-0580. *Inquiring about Inquiry: Progress on Research and Evaluation Studies of Inquiry-Based Learning in Undergraduate Mathematics at Four Campuses.*

Four university mathematics departments are part of an initiative to improve undergraduate mathematics teaching and learning by developing and teaching courses using inquiry-based learning (IBL) approaches. We are collaborating with these departments to study the outcomes for students who take these IBL courses, including students' growth in mathematical learning and thinking, changes in attitudes, confidence, or beliefs about mathematics, and their subsequent educational and career choices. The IBL courses being studied primarily address two important populations: mathematics, science, and engineering majors taking courses that introduce them to proof and higher mathematical thinking; and pre-service teachers at the elementary and secondary levels who are taking courses focused on the mathematics they will need for teaching. We will describe the goals and design of the study and will present preliminary findings as available from data gathered in the earliest stages of the study, which began in 2008. The study is part of the Inquiry-Based Learning Mathematics Project and is undertaken with the support of the Educational Advancement Foundation. (Received September 16, 2008)

1046-97-755 **Danielle M Goodwin*** (dgoodwin@vinu.edu), 1002 N. First St., Vincennes, IN 47591. *What Do MD & VA Teachers Believe About Mathematics and What Do They Know About Mathematics History?*

This study reveals what Maryland and Virginia K-12 teachers believe about mathematics, what they know about mathematics history, and the significant correlational relationships between level of mathematics history knowledge and beliefs about mathematics. Maryland and Virginia teachers believe that mathematics is fun, thought-provoking, and intricately connected to the real world. They disagree with statements like "everything important in mathematics is already known" and "mathematics is a disjointed collection of facts, rules, and skills." Teachers with high history scores were more likely to strongly agree that mathematics makes a unique contribution to human knowledge and disagree that mathematics can be separated into different areas with unrelated rules. This large-scale correlational study (N=168) is part of an ongoing national study (with over 2,000 respondents so far) which shows that there is indeed a relationship between teachers' knowledge of mathematics history and their images of mathematics, as claimed by many theorists, and that further research is needed to test a causal relationship. (Received September 10, 2008)

1046-97-779 **Bill Jacob*** (jacob@math.ucsb.edu), Mathematics Department, University of California, Santa Barbara, Santa Barbara, CA 93106. *Inquiry about Inquiry: Use of case studies to develop mathematical ideas in courses for pre-service teachers.*

K-12 teachers need a deep and interconnected knowledge base in mathematics. This presentation will illustrate how analysis of children's mathematical work can be used to develop key topics in mathematics courses for pre-service teachers. Since the children in the cases are engaged in mathematical inquiry, and the pre-service teachers in the course are set to work to uncover the children's strategies and the mathematical relations between the strategies, we call this "inquiry about inquiry". (Received September 11, 2008)

1046-97-789 **Cindy C. Kaus*** (cindy.kaus@metrostate.edu), Metropolitan State University, 700 East Seventh Street, Saint Paul, MN 55106. *Teaching Introductory Statistics with Community Based Group Projects and Assessing with the SENCER-SALG.*

Through support from the NSF sponsored project, Science Education for New Civic Engagements and Responsibilities (SENCER), I have developed a general education statistics course which incorporates semester long community based group projects. The projects are used to reinforce content and to help students see the significance of mathematics and statistics in understanding civic issues. Students choose topics based on interest level, collect and analyze data, present their findings to the class in an oral and written presentation and take an action through letter writing to a local newspaper, community group, or elected official. In addition to the projects, connections to civic issues and statistics are explored through lecture examples and analysis of current events.

In this session, I will discuss the outcomes from teaching this course during the spring and fall semesters of 2007 and the results from the pre and post SENCER Student Assessment of Learning Gains (SENCER-SALG) instrument. The SENCER-SALG assesses students' attitudes towards mathematics and statistics and their confidence in their abilities to understand and do mathematics and statistics. I will also discuss my future plans for developing and implementing pre and post knowledge surveys. (Received September 11, 2008)

1046-97-847 **David E. Meel*** (meel@bgsu.edu), Department of Mathematics & Statistics, Bowling Green State University, Bowling Green, OH 43403. *Collaborative Concept Mapping in Calculus.*

In this talk, examples of collaborative Calculus concept maps and the individual concept maps that support them will be examined. In particular, we will look at the particular cognitive structures displayed in the concept maps and how the collaboration negotiated meaning amongst the participants. Of particular importance will be the shared understandings that were presented in the collaborative concept map that was not originally part of all the members of a group but through discussion, and sometimes argumentation, became accepted knowledge for the group. (Received September 12, 2008)

1046-97-848 **Joseph Malkevitch*** (malkevitch@york.cuny.edu), Department of Mathematics, York College (CUNY), Jamaica, NY 11451. *Discrete, Combinatorial, and Computational Geometry for Undergraduates.*

Axiomatic, historical, and metrical approaches to geometry dominate the way geometry is currently taught to undergraduate mathematics majors. However, mathematics majors are disadvantaged by this approach whether they plan to become industrial mathematicians, teach pre-college mathematics, or hope to do research in geometry as part of doctoral studies. The goals of teaching geometry for mathematics majors can best be accomplished by a modified approach to traditional geometry curriculum which will incorporate non-metrical ideas along with metrical ones. (Received September 12, 2008)

1046-97-853 **James Sandefur*** (sandefur@georgetown.edu), Department of Mathematics, 317 St. Mary's Hall, Gerogetown University, Washington, DC 20057, **Connie M Campbell** (campbcm@millsaps.edu), Millsaps College, 1701 N. State Street, Box 150086, Jackson, MS 39210, **Kay Somers** (mekbs01@moravian.edu), Department of Mathematics and Computer Scienc, Moravian College, 1200 Main Street, Bethlehem, PA 18018, **Manya Raman** (manya.sundstrom@educ.umu.se), Department of Mathematics, Technology, and Sc, Umeå University, SE-901 87, Umeå, Sweden, and **Geoffrey D. Birky** (gdb29@georgetown.edu), Department of Mathematics, 345 St. Mary's Hall, Georgetown University, Washington, DC 20057. *Using Video Case-Studies to Enhance Both Teaching and Learning in a Transition Course.* Preliminary report.

The presenters, three mathematicians and two mathematics educators from four different schools, are involved in an on-going project designed to deepen our understanding of how students learn to construct proofs. We have developed a collection of think-aloud videos of students working in groups to prove theorems for use as case-studies in transition courses, with the theory that students' proof-skills will improve through reflection on students in the video. Qualitative data on use of these video-case studies in classrooms includes videos of classroom use, individual and group interviews with teachers and students, written records of student work, and video records of discussions among the research team. The presenters will show one of the case-study videos and report on what they have learned about the use of this video as well as the videos in aggregate. (Received September 12, 2008)

1046-97-876 **Scott Crass*** (scrass@csulb.edu). *Math as Exploration.* Preliminary report.

The Long Beach Project in Geometry and Symmetry provides students with the chance to experience math as an exploratory process. Supported by an NSF-CCLI grant, its centerpiece is a *Geometry Studio.* Housing a variety of tools, the studio is a space where students and faculty gather to construct, discover, and explore models and structures connected to mathematical ideas and results. A fundamental objective is to encourage students to develop experimental, perceptual and geometric modes of thinking.

I will focus on an upper-division course in the standard curriculum that's been offered as a "studio experience." *Modern Geometry* is populated mostly by students preparing for high-school teaching. The class engages in a number of explorations each of which begins with a question of a fairly simple and experiential nature. What are the maximally symmetric polyhedra? Can one knot be turned into another? How do you render a three-dimensional object on a plane? Working by collaborative experimentation and exploiting the studio's material resources, students then develop independent ways of thinking about the issues. Frequently, they arrive at new questions or refine the original one. The class gains insight and understanding through an ensuing class-wide discussion. (Received September 12, 2008)

1046-97-938 **Mariah Birgen*** (mariah.birgen@wartburg.edu), 100 Wartburg Blvd., Waverly, IA 50677. *Mathematics + SENCER = Student Learning.*

Science Education for New Civic Engagements and Responsibilities (SENCER) is a comprehensive national dissemination project funded by the NSF. This presentation will be an introduction to SENCER followed by some discussion issues specific to mathematics.

The goal of SENCER is to engage student interest in the sciences and mathematics by supporting the development of undergraduate courses and academic programs that use "best practices" in order to teach basic science and mathematics "through" complex, capacious, and unsolved public issues. Assessment has been embedded within the SENCER project from day 1, including requiring every funded project to use a special Student Assessment of Learning Gains tool. Each year, the project holds an Institute for faculty that includes a deliberate introduction to the Scholarship of Teaching and Learning.

Since 2000, SENCER has promoted many science courses, but until recently has found a dearth of undergraduate mathematics (or quantitative literacy) courses that work on the same model. Many mathematicians are teaching math courses through issues civic engagement and we would like to connect with you. (Received September 12, 2008)

1046-97-962 **Daina Taimina*** (daina.taimina@cornell.edu), Department of Mathematics, Malott Hall, Cornell University, Ithaca, NY 14853-4201. *Exploring two-dimensional manifolds with crochet hook.*

Crocheted models of the hyperbolic plane are very inviting to play with. There are many different ways to fold symmetric hyperbolic planes. Starting from the same basic plane, there are unlimited possibilities to create different fiber sculptures. Do these different shapes have anything to do with mathematics or are they just purely aesthetic forms? All those surfaces are geometric 2-manifolds. Each of them is covered by the hyperbolic plane and so each is locally isometric to the hyperbolic plane (and to each other). However, among these geometric 2-manifolds, only the hyperbolic plane is simply connected—all the other hyperbolic surfaces have holes or circles that cannot be shrunk on the surface. In the first /Fiber Arts in Mathematics and Mathematics Education/ session I showed crocheted hyperbolic octagon that forms a two-manifold. In this talk I will show how to make two-manifolds from crocheted hyperbolic rectangular hexagons and ideal triangles. (Received September 13, 2008)

1046-97-990 **W James Lewis*** (jlewis@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 685880130. *Math in the Middle Institute Partnership.* Preliminary report.

Math in the Middle is an NSF-funded Math Science Partnership Institute for middle-level mathematics teachers at the University of Nebraska-Lincoln. The Institute seeks to develop teachers' mathematical knowledge for teaching, knowledge of effective classroom pedagogy, leadership skills, and an understanding of action research, with the goal of enabling graduates to become intellectual leaders in their local schools and districts. Teachers in the institute take seven mathematics courses, one statistics course, three education courses and one integrated math and education capstone course and earn a Master's Degree from UNL. To date, 93 teachers have earned a Master's Degree through the Institute. We will discuss the design of the institute and offer a closer look at two of the mathematics courses that have been developed for use in the Institute. (Received September 13, 2008)

1046-97-1002 **Ralf J Spatzier*** (spatzier@umich.edu). *Inquiry Based Learning at University of Michigan.* Preliminary report.

Several inquiry based mathematics courses have been developed at the University of Michigan in the last few years. They span all the way from math education to an freshmen seminar on cryptology to a class exploring math research. We will discuss some of these classes and their assessment. (Received September 13, 2008)

1046-97-1111 **Kristin A Camenga** (kristin.camenga@houghton.edu), Houghton College, 1 Willard Ave., Houghton, NY 14813, and **Kien H Lim*** (kienlim@utep.edu), Dept. of Mathematical Sciences, University of Texas at El Paso, El Paso, TX 79968-0514. *Panel: Helping Students Develop Mathematical Habits of Mind.*

As teachers, we are entrusted to teach the long list of mathematical concepts specified in the syllabus. In addition to the tension between depth and breadth, we need to incorporate into our lessons opportunities for students to develop mathematical habits of mind. According to Cuoco, Goldenberg, and Mark, the goal of a habits of mind curriculum is to help "students learn and adopt some of the ways that mathematicians think about problems." This goal, although challenging, is attainable. In this panel discussion, the presenters for this session will discuss (a) ways for helping students cultivate mathematical habits of mind while learning key mathematical concepts across grade levels from elementary to college, and (b) strategies for addressing the challenges in implementing a habits of mind curriculum. (Received September 15, 2008)

1046-97-1221 **Angela Mejeur*** (angela.mejeur@navy.mil). *Job Opportunities for Mathematics students in the Navy Labs.*

The United States Navy employs thousands of civilian Mathematicians, Scientists, and Engineers throughout its many research, development, and testing laboratories. A discussion on job opportunities, challenges, and applicant criteria and skills for math graduates will be presented. (Received September 15, 2008)

1046-97-1249 **Daniel I Chazan*** (dchazan@umd.edu), 2226C Benjamin Building, University of Maryland, College Park, MD 20742. *Teaching students to be life-long learners of mathematics: Algebra I and Mathematics for Mathematics Education Doctoral Students.*

Recent scholarship on learning (see, e.g., www.ewenger.com) suggests that we consider identity in addition to cognition. In this talk, I will present my efforts to help students, both lower track Algebra 1 students in high school and mathematics education doctoral students, to become life-long learners of mathematics. As a result of their different educational trajectories, the nature of the tasks used to support these different kinds of learners are different, but there is a similarity in my attempts to explore issues of identity in order to understand and predict how students will respond to the tasks I create for them. The presentation will describe a project for high school students that used the notion of repeated calculations on measured or counted quantities to generate a new quantity, as a vehicle for finding mathematics in the world around them. It will also share the outline of a course for mathematics educational doctoral students and illustrate how students were engaged in the study of continued fractions. This study was intended to provide an experience doing research in mathematics, as well as providing a deeper understanding of issues in the representation of number. The students also viewed this study as an illustration of a particular kind of pedagogy. (Received September 15, 2008)

1046-97-1259 **Edward Odell*** (odell@math.utexas.edu), The University of Texas at Austin, Mathematics Department, 1 University Station C1200, Austin, TX 78712. *IBL Analysis at The University of Texas.* Preliminary report.

We discuss the history of implementing IBL analysis at UT over the past four years. The discussion will cover the actual construction of the problem sets as well as the inculsion and mentoring of other faculty and graduate students. (Received September 15, 2008)

1046-97-1341 **Stan T Yoshinobu***, stanyoshinobu@mac.com. *Restraint and Coverage: A Characterization of Instructor Change.*

This talk will highlight a case study of 7 college mathematics instructors, trained to implement inquiry-based learning in a weeklong summer workshop. Each instructor implemented inquiry-based learning differently in an upper-level mathematics course. Some instructors chose to use a hybrid approach, mixing traditional methods and inquiry, while others implemented a full inquiry-based learning course. We examine how instructor restraint and concerns about covering enough topics significantly influence instructor decisions about course structure and day-to-day teaching. A framework is also presented to classify instructors along a continuum. (Received September 15, 2008)

1046-97-1380 **Paul J. Sally*** (sally@math.uchicago.edu), Mathematics Department, University of Chicago, 5734 S. University Avenue, Chicago, IL 60637. *Outreach IBL at the University of Chicago.*

Starting three years ago, the University of Chicago began offering IBL in two of its outreach programs. The first is the UTEP program for the preparation of elementary school teachers, and the second is the Young Scholars Program aimed at mathematically talented high school students. During the current year, the IBL format is being introduced in a sixth grade class in a Chicago public elementary school by a teacher who works with the Mathematics Department in its various outreach programs. We will discuss these three programs. (Received September 15, 2008)

1046-97-1401 **Karen A. Marrongelle*** (kmarrong@nsf.gov) and **Larry Suter** (lsuter@nsf.gov). *A Review of NSF-supported Research and Development on Instructional Innovations in Undergraduate Mathematics Education.* Preliminary report.

This presentation focuses on examining the NSF undergraduate portfolio in mathematics instruction and learning that has been awarded in the Directorate for Education and Human Resources. Presenters will discuss how the undergraduate mathematics research and development projects are intended to provide groundwork of theory and scientific rigor for many of the recommendations for best teaching practices in mathematics. The authors will discuss the nature of evidence resulting from these NSF-funded projects in fields of mathematics. Presenters will address the NSF Education and Human Resources portfolio's gaps in mathematics content, course innovations, and methodology, developing insights into the current activities and projects underway in American colleges and universities.

Funded projects have been classified as addressing course innovations or research in the areas of: (1) Instructors and Professional Development; (2) Instructional Practices; (3) Instructional Materials; (4) Assessment of Student Learning; and (5) Technology. For example, projects may introduce research or development of topics such as lecture or cooperative learning. Other projects include visualizations and applying principles of design research to develop and refine inquiry-based curricula. (Received September 15, 2008)

1046-97-1431 **David L. Ferguson*** (David.Ferguson@stonybrook.edu), Department of Technology and Society, College of Engineering and Applied Sciences, Stony Brook University, Stony Brook, NY 11794-3760. *Mathematical and Statistical Reasoning in Compelling Contexts.*

Many students with interests outside of "quantitative fields" perceive much of school and college mathematics as dull, difficult, scary and totally irrelevant. For these students, mathematics is a "necessary evil," or a dreaded game, rather than a subject to be enjoyed and integrated into their personal and professional lives. What, then, are the challenges of bringing mathematical and statistical reasoning into richer contexts so that students with multiple interests, strengths, purposes and worldviews might see the beauty and understand the uses and abuses of quantitative approaches? This presentation will focus on the use of modeling and decision making in enhancing students' abilities to do quantitative reasoning. (Received September 15, 2008)

1046-97-1481 **Bernadette Mullins*** (bmullins@bsc.edu), Department of Mathematics, Birmingham-Southern College, Birmingham, AL 35254, and **John Mayer**, **Tommy Smith** and **Rachel Cochran**. *The impact of challenging mathematics courses on middle school teachers.* Preliminary report.

The Greater Birmingham Mathematics Partnership offers a series of summer mathematics courses for in-service teachers. These intensive two-week courses focus on mathematics content and model inquiry-based pedagogy. This study concerns the impact of these courses in terms of changes in teacher content knowledge, teacher classroom practice, and student achievement. Instruments include the test of Content Knowledge for Teaching Mathematics, the Reformed Teaching Observation Protocol, SAT-10, and the Alabama Reading and Mathematics Test. (Received September 15, 2008)

1046-97-1489 **Catherine A Matos*** (catherinematos@clayton.edu), 2000 Clayton State Blvd, Morrow, GA 30260, and **Mary Hudachek-Buswell** (MaryHudachek-Buswell@clayton.edu), 2000 Clayton State Blvd, Morrow, GA 30260. *The Hybrid Mathematics Class: The best of both worlds, or No Man's Land?*

In response to increasing demands on student and university resources, the hybrid mathematics class is growing in popularity. For Hybrid courses, classes meet one period a week for traditional instruction, with the balance being completed online. But is this a good option for students? The presenters will discuss their experiences in teaching hybrid versions for two entry level courses, College Algebra and Introductory Statistics. What changes must be made to how the class is run? How do students react to this format? The pros and cons of this type of course format will be presented. The impact on student performance will be assessed through exam scores and DWF rates. (Received September 15, 2008)

1046-97-1495 **Tristan M Denley*** (tdenley@olemiss.edu), Department of Mathematics, University of Mississippi, PO Box 1848, University, MS 38677. *How redesigning freshman classes can impact a whole department.*

There has been much interest recently in Course Redesign and its impact on the quality of introductory mathematics classes. The University of Mississippi has been one of the pioneers of this type of education. In this talk we will share not only the impact of these changes to the quality of education, but also how the freed resources have radically impacted the department's undergraduate and graduate programs, resulting in a doubling of the number of majors and 23 PhD's over the last 5 years. (Received September 15, 2008)

1046-97-1545 **Stephanie R Nichols*** (stephanie.nichols@anokaramsey.edu), Anoka-Ramsey Community College, Mathematics Department, 300 Spirit River Drive, Cambridge, MN 55008. *Student-to-Student Discussions: The Roles of the Instructor and Students in Discussions in an Inquiry-Oriented Transition to Proof Course.*

This study of student-to-student discussions focuses on an inquiry-oriented transition to proof course at a large southern university. Mathematical proof is 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. Although this link has been established, there is very little research on the role of students and the instructor during discussions on student-generated proofs at the undergraduate level. This research analyzes the types of discussions that occurred in an inquiry-oriented undergraduate mathematics course in which proof was the main content. These discussions fell along a continuum based on the level of student interaction. As a result of this research, the four main discussion types that were present in this course have been described in detail with a focus on the roles of the instructor and the students. In addition, an analysis of the types of discussions relative to the difficulty of the content revealed that students can and do talk about difficult content when given the opportunity. (Received September 16, 2008)

1046-97-1550 **Wendy Hageman Smith*** (smithwh@longwood.edu), 808 5th Street, Radford, VA 24141. *A Constructivist Theory of Teaching Mathematics: from concept to context.*

This paper is meant to introduce a theory of teaching mathematics based on constructivism, which has an epistemological basis. Constructivism has been used as a framework to form cognitive theory and attempts to explain the specific mechanisms by which we acquire knowledge. The basic tenet is that all knowledge is constructed by the individual, that is, it must be 'formed' in the mind and cannot simply be 'acquired' by direct transmission. This is of course directly relevant to our profession as educators, for to teach well we must be able to understand how students learn, so that we can develop and employ methods that work. The NCTM Professional Standards for Teaching Mathematics (1991) adumbrates a framework for a theory of teaching when it presents six elements of teaching that need to be addressed by educators and offer much of what a theory of teaching should include, but they do not constitute a theory of teaching, per se, because they omit the basic tenets upon which such standards should be based. My theory expands from the six areas included in the Professional Standards, and over the past few years I have been doing research on how this theory of teaching mathematics can be used by different educators in their classrooms. The results have been promising. (Received September 16, 2008)

1046-97-1553 **David Barker** (dbarker@ilstu.edu), Campus Box 4520, Department of Mathematics, Illinois State University, Normal, IL 61790-4520, and **Saad I El-Zanati*** (saad@ilstu.edu), Campus Box 4520, Department of Mathematics, Illinois State University, Normal, IL 61790-4520. *Teacher-Scholars: Research Experiences for Pre-service and In-Service Secondary Mathematics Teachers.* Preliminary report.

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 is a year-long capstone research experience. The other is an REU Site for both pre-service and in-service teachers. Both programs are collaborative efforts between mathematicians and mathematics educators. Our work shows that secondary education majors are capable of undergraduate research in mathematics and benefit from the experience. The experience of doing mathematics has caused a change in our teachers' views of the nature of mathematics. This change has resulted in subsequent changes in their beliefs about teaching and learning. (Received September 16, 2008)

1046-97-1561 **Robert E. Wieman*** (rwieman@vsu.edu), Department of Mathematics & Computer Science, P.O. Box 9068, Virginia State University, Petersburg, VA 23806. *Refocused Algebra versus POGIL: Chemistry's Solution and What Mathematics can Derive from it.*

POGIL (Process Oriented Guided Inquiry Learning, www.pogil.org) is a pedagogical approach based on small self-managed student groups working on guided inquiry projects. The approach was developed by chemistry professors, and is known and applied primarily in that field.

The MAA/CUPM Subcommittee On Curriculum Renewal Across The First Two Years (CRAFTY) has recommended College Algebra Guidelines which include "providing student-centered, activity-based instruction, including small group activities and projects". To encourage this refocusing of introductory college mathematics courses, Don Small has written *Contemporary College Algebra*, a textbook including many projects for small student groups.

We evaluate the structure and principles of POGIL projects, with the aim of borrowing and customizing features of POGIL so that they can be applied to a refocused college algebra course. We focus on POGIL's explicit team structure and emphasis on process skills such as leadership, conflict resolution, and time management, because these may offer solutions to some of the common difficulties encountered in team-based learning environments. (Received September 16, 2008)

1046-97-1598 **Gerard A Venema*** (venema@calvin.edu), Department of Mathematics, 1740 Knollcrest Circle SE, Calvin College, Grand Rapids, MI 49546. *A course in axiomatic geometry.*

In this talk I will make the case for a course in axiomatic geometry aimed at undergraduate mathematics majors. I believe that most of the traditional reasons for teaching such a course are still valid and that there are some new ones besides. Other issues to be addressed include the choice of axioms, the role of technology in a course in axiomatic geometry, and how to meet the specific needs of future high school teachers. (Received September 16, 2008)

1046-97-1657 **Derek Bruff*** (derek.bruff@vanderbilt.edu), Peabody Box #183, Vanderbilt University, Nashville, TN 37203. *Making the Most of Pre-Class Reading Assignments in Statistics.*

What are students in a probability and statistics course for undergraduate engineering majors likely to learn by reading their textbook before class? What kinds of pre-class reading quiz questions, answered by students online the night before class, are likely to help such students learn more from reading their textbook? These questions are investigated by analyzing student responses to pre-class reading quizzes, which consist of questions about notation, conceptual questions, computational questions, and "muddiest point" questions asking students to name a question they have about the reading. Initial results indicate that asking computational questions on pre-class reading quizzes helps students learn both computational and conceptual material from reading their textbooks, moreso than pre-class conceptual questions. This somewhat surprising result has implications for the role of conceptual and procedural learning in statistics courses. In addition, coding schemes for analyzing student responses to the "muddiest point" questions are being developed. One scheme offers a method for assessing how much insight into a student's thought processes a particular response provides. Another scheme will help detect signs of "deep learning" in student responses. (Received September 16, 2008)

1046-97-1675 **Kien H Lim*** (kienlim@utep.edu), Department of Mathematical Sciences, University of Texas at El Paso, El Paso, TX 79968-0514. *Undesirable Habits of Mind of Pre-service Teachers: Strategies for Addressing Them.*

In order to help students develop mathematical habits of mind teachers must possess those habits themselves. Many pre-service K-8 teachers, however, enter colleges with undesirable habits of mind such as spontaneously proceeding with an action that comes to mind without analyzing the problem situation, and not attending to meaning of numbers and symbols. Such habits of mind will negatively impact what and how they learn. For example, students tend to focus on procedures for solving problems rather than on their underlying mathematical structures. A study is being conducted to investigate the viability of posing problems for which a recently learned idea would not work to foster the habit of identifying quantities and relationships among quantities. Preliminary results show that habits of mind are resistant to change. (Received September 16, 2008)

1046-97-1739 **Jack Bookman*** (bookman@math.duke.edu), Mathematics Department Duke University, Box 90320, Durham, NC 27708-0320. *Questions You Might Want Answered Using Data from the Registrar.*

A description of a simple study conducted to answer questions intended to examine some long held and unexamined assumptions about first year calculus students. In particular, their performance in Calculus III as second year students and the number who persist to earning undergraduate degrees in mathematics was examined. This will be followed by a discussion on how these results were communicated to various members of the department - instructors, graduate students and research faculty - and how various members responded (or didn't). The discussion will conclude with some other questions that we have addressed using data from the registrar. (Received September 16, 2008)

1046-97-1758 **Andrew G Bennett*** (bennett@math.ksu.edu), Department of Mathematics, Cardwell Hall, Kansas State University, Manhattan, KS 66506. *What makes effective online feedback in college algebra?* Preliminary report.

We have a system where students submit work to an online system that provides for repeated practice, with feedback available at various stages. We have applied data-mining techniques to study which students will use feedback and how, with the goal of understanding how to make the feedback a more effective learning tool. The focus will be on college algebra, though we may discuss other classes as well. (Received September 16, 2008)

1046-97-1774 **Chris Rasmussen*** (chrisraz@sciences.sdsu.edu), 5500 Campanile Drive, Dept of Mathematics and Statistics, San Diego, CA 92182-7720. *Classroom Norms and Habits of Mind.*

In this report I argue that individual dispositions (or habits of mind) and classroom social and sociomathematical norms evolve together as a dynamic system. In doing so, neither the social nor the psychological perspective is given primacy. Rather, each perspective provides a backdrop against which to consider the other. In particular, I discuss the Cobb and Yackel's (1996) interpretive framework, giving specific attention to student's dispositions and corresponding classroom norms using as an example a university level differential equations class to clarify and illustrate constructs within the framework. The example demonstrates both the normative aspects of the classroom and the corresponding student dispositions, demonstrating how the theoretical constructs of the interpretive framework can be used to explain change in a student's habits of mind. Pragmatically, I argue that one way to give explicit attention to student dispositions in the mathematics classroom is to be deliberate about initiating the negotiation of classroom norms. (Received September 16, 2008)

1046-97-1846 **Guadalupe I Lozano*** (guada@unm.edu). *Understanding, abstracting, and building upon students' mathematical reasoning: a new course for prospective elementary and middle school Teachers.* Preliminary report.

In this talk I discuss a new mathematics topics course for undergraduate prospective teachers (PTs). The course's goal is to engage PTs in the practice of analyzing, evaluating, and building upon creative student-generated solutions to routine and non-routine mathematics problems. The course was created so as to address the gap between teachers' mathematics content knowledge and the application of that mathematics content knowledge to promoting and supporting reform-based practices (Ball & Bass, 2000; Hill, Ball & Schilling, 2008). In this presentation, I discuss the specific design, theoretical, and practical underpinnings of this course. I also explain why the approach is novel and relevant for prospective teacher education at the college level. Preliminary analysis of PTs' feedback indicates that PTs felt the course not only expanded their own mathematics content-knowledge base but also provided them with specific tools to help potential students reflect upon meaning-based misconceptions. Pre and post-tests suggest that PTs may have improved their ability to reason about non-traditional solutions that fall within the topics discussed in the course, but not in a manner that sustains a clear transfer of this ability to other mathematics topics. (Received September 16, 2008)

1046-97-1874 **William Barker*** (barker@bowdoin.edu), Department of Mathematics, Bowdoin College, 8600 College Station, Brunswick, ME 04011-8486. *Panel on Teaching Undergraduate Geometry: Choices in Philosophy, Content, and Pedagogy.*

This portion of the AMS-MAA-MER Special Session on Mathematics and Education Reform has featured speakers with a variety of viewpoints on the philosophy, content, and format of courses in undergraduate geometry. This concluding panel discussion will allow for a lively exchange between the speakers and direct dialogue with the audience. The panel members will be Scott Crass (Cal State, Long Beach), David Henderson (Cornell), Roger Howe (Yale), Joseph Malkevitch (CUNY), and Gerald Venema (Calvin College). Cosponsored by the Committee on the Undergraduate Program in Mathematics (CUPM). (Received September 17, 2008)

1046-97-1880 **Yvonne Lai***, laixl@umich.edu, **Hillel M Raz**, hraz@math.ucdavis.edu, and **Marion Moore**, marion@math.ucdavis.edu. *Teaching Math Majors How to Teach.*

This project was motivated by a desire to understand how students, in particular math majors, view teaching and preparing how to teach. We report on a small seminar program in which a few mathematics undergraduates worked with graduate students at a weekend outreach program for high school students. During the pilot year 2007, we found that the undergraduate participants were uniformly surprised that teaching requires mathematical and pedagogical foresight. Additionally, while they were curious about techniques such as group work, in practice, they were hesitant to use them out of lack of confidence. These observations informed the design of the 2008 seminar, in which all participants became more comfortable teaching in a "non-traditional" classroom setting. We will discuss the design of the 2008 seminar, share some stories about the undergraduate participants' insights into the process of becoming teachers, and how this influenced the design of the 2009 seminar. (Received September 16, 2008)

1046-97-1906 **Hyman Bass*** (hybass@umich.edu), 2413 School of Education, 610 E. University, Ann Arbor, MI 48109-1259. *Algebraic reasoning in 3D, using principles of linearity and symmetry.*

Mathematical habits of mind make use of mathematical connections (for example between algebra and geometry), recognition and use of patterns (such as linearity, symmetry, etc), and multiple (including visual) representations.

Yet much of the school curriculum is restricted to shallow and disconnected engagements with these ways of thinking. I propose to show an example of a rich piece of mathematical reasoning and problem solving that integrates all of these features, yet uses only resources available in the middle school curriculum. (Received September 16, 2008)

1046-97-1919 **James M Haley***, 815 Copeland Way, #4D, Pittsburgh, PA 15232. *Possible Evolutions of Financial Markets in a Keynesian Economy.*

This paper identifies the necessary monetary policy conditions to prove the existence of a strange attractor or a rational expectations equilibrium in a Keynesian macro model of the economy. Specifically, a Rossler nonlinear model perturbed by noise exists for financial markets, if the Federal Reserve, the US central bank, implements a Taylor-like monetary policy. In this regime the Fed targets the federal funds rate, which controls interest rates, to vary directly with inflation expectations and real output. Often the Fed overreacts by setting interest rates too high or too low, causing chaotic business cycles to emerge. Instead, if the Fed follows a Wicksell rule by targeting zero inflation expectations and pegging the federal funds rate to equal its real expectation, the stock market will behave like a Langevin equation. In this case the density of real stock returns is asymptotically normal. Consequently, business cycles no longer exist, since the stock market and the economy mean-revert. Then everyone can make more reliable forecasts. (Received September 16, 2008)

1046-97-2036 **Scott J Baldridge*** (sbaldrid@math.lsu.edu), 224 Lockett Hall, Department of Mathematics, Louisiana State University, Baton Rouge, LA 70817, and **Johnette Winfrey** (JWinfrey@bakerschools.org), Baker Heights Elementary School, 3750 Harding Street, The City of Baker, LA 70714. *Building a high-performing mathematics program in the City of Baker using the Singapore mathematics curriculum.* Preliminary report.

This talk is about a project to help the mathematically low-performing Baker school district in Louisiana in an attempt to create a replicable model for creating high-performing mathematics programs in the U.S. There are two features of this project that make it unique: (1) The district is implementing the Primary Mathematics Curriculum, a highly-rated mathematics curriculum for grades K-5 from Singapore (referred to in the nation press as "Singapore Math"), and (2) the project uses mathematics graduate students to support the implementation of the curriculum and to provide work-embedded professional development on a daily basis to improve teacher's content and mathematical teaching knowledge. In this talk we will describe this ambitious project and discuss some of the issues we faced in the first year of this project. (Received September 16, 2008)

1046-97-2072 **Scott J Baldridge*** (sbaldrid@math.lsu.edu), 224 Lockett Hall, Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, and **Thomas H Parker** (parker@math.msu.edu), Wells Hall, Department of Mathematics, Michigan State University, Lansing, MI 48824. *Instructor Resources for Elementary Mathematics for Teachers.* Preliminary report.

There is a growing body of evidence that teacher effectiveness is a function of a very specialized and complex knowledge that goes under various names such as Shulman's "pedagogical content knowledge", Liping Ma's "profound understanding of fundamental mathematics", or more generally, "mathematics knowledge for teaching". Creating interesting and effective problems for a college course on elementary mathematics for teachers that instructors can use to evaluate students' understanding of this knowledge poses special challenges. In this talk we will present some examples of math problems for elementary teachers that illustrate these challenges. We will also describe a newly-created website (iremt.math.msu.edu) that contains problem banks, an online test/assessment generator program, and lesson guides that can be used to help instructors meet these challenges. The website was created as part of a collaborative NSF CCLI grant between Louisiana State University and Michigan State University. (Received September 17, 2008)

1046-97-2075 **Deborah Loewenberg Ball*** (deborahball@umich.edu), School of Education, University of Michigan, Ann Arbor, MI 48109-1259, and **Hyman Bass** (hybass@umich.edu), Department of Mathematics, University of Michigan, Ann Arbor, MI 48109-1259. *MIME at IM&E: Professional Development for Mathematicians in Mathematics Education.*

Demand is increasing for mathematicians who can constructively contribute to work in mathematics education, such as standards development, validation of tests, curriculum design, textbook review, and the preparation and professional development of teachers.

MIME workshops at the Institute for Mathematics and Education orient mathematicians on key knowledge, skills, and policy areas: the core mathematics of K–12, mathematical knowledge for teaching, the nature of the educational system, the profusion of standards documents, the variety of curricula, and mathematics education research.

This talk will present that background that lead to the development of the MIME concept, and report on the first workshop held in March, 2008. (Received September 17, 2008)

1046-97-2077 **William G McCallum*** (wmc@math.arizona.edu), Institute for Mathematics and Education, Department of Mathematics, The University of Arizona, Tucson, AZ 85721. *The Work of the Institute for Mathematics and Education in Developing Partnerships between Mathematicians, Educators, and Teachers.*

The Institute for Mathematics and Education was founded in 2006 with 5 years of start-up funding from The University of Arizona. It is guided by three principles: its projects must be

- grounded in the work of teachers
- informed by a deep knowedge of mathematics
- conducted as collaborations between all involved in mathematics education.

This talk will report on workshops conducted during the first full year of operation of the Institute, covering the use of case studies in teacher preparation, and mathematics courses for elementary and secondary teachers. We will describe the results of these workshops, and work which is ongoing as a result of them. (Received September 17, 2008)

1046-97-2090 **Robin Leigh Blankenship*** (r.blankenshi@moreheadstate.edu), 150 University Blvd, 201C Lappin Hall, Morehead State University, Morehead, KY 40351. *What will students do for 1 point in the land of no bonus?* Preliminary report.

After careful analysis of the results of years of offering bonus opportunities, I decided this approach was not producing the desired results of motivating students to excel. Active students remained active, and vice versa. Simultaneously, my efforts to conduct class using inquiry-based methods and my student presentation requirements were met with considerable resistance. This year, I created a new system of awarding 1 point for a wide variety of individual and collective achievements, which the students collect like monopoly money. At the end of the semester, they can ask me to delete their choice of missing or low quiz grades, and then trade in points to replace the grade. Examples of 1-point opportunities and exciting classroom participation results will be described. (Received September 17, 2008)

1046-97-2091 **David gu*** (gu@cs.sunysb.edu), Computer Science Department, SUNY at Stony Brook, Stony Brook, NY 11794-4400, and **Feng Luo** (fluo@math.rutgers.edu), Department of Mathematics, Rutgers University, Piscataway, NJ 08854. *Discrete curvature flows and their applications, II.* Preliminary report.

This presentation introduces the concepts, theories and algorithms of discrete curvature flows for surfaces with arbitrary topologies, including discrete Ricci flow and Yamabe flow. Discrete curvature flow for hyperbolic 3-manifolds with geodesic boundaries is also presented.

Curvature flow method can be used to design Riemannian metrics by prescribed curvatures, and applied for parameterization in graphics, shape registration in computer vision, brain mapping in medical imaging, spline construction in computer aided geometric design, and many other engineering filelds. (Received September 17, 2008)

1046-97-2113 **Paul Goldenberg*** (pgoldenberg@edc.org). *Mathematical habits of mind and the language-learning brain: mathematicsas a second language.*

Language plays a surprising behind-the-scenes role in elementary arithmetic. Numbers weren.t born with names. We named them, and we did so in a way that simplifies mathematical thinking by allowing certain mathematical ideas to be handled as if they were purely linguistic ones. The actions of the language-brain are less subtle in algebra. Algebra is both a set of ideas and a language in which to express them. We use the language aspect of it first to describe things we already know.an essentially semantic use of the language. Then, by manipulating these descriptions strategically according to the syntax of the language, we can derive things we did not previously know.

Young children, for the most part, cannot take that second algebraic step, using abstract manipulations to derive what they don.t know. Because that is such a central part of the way we see algebra, we tend to overlook the descriptive side of algebra that young children can learn easily and excel at. In fact, young children are the best linguists of us all and, given the chance, can put their linguistic talents to good use in learning mathematics: not only in learning the language-part of algebra much the way they learn their native language, but also in understanding number, and in performing certain computations.

This talk will illustrate several mathematical ways of thinking that have linguistic roots, and suggest an approach.in successful use.that explicitly takes advantage of those roots. (Received September 17, 2008)

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 Lecturers, and Presentations by Teaching Award Winners

1046-A0-10 **Ivars Peterson***, MAA, Washington, D.C. *Geometreks.*
Few people expect to encounter mathematics on a visit to an art gallery or even a walk down a city street (or across a campus). When we explore the world around us with mathematics in mind, however, we see the many ways in which mathematics can manifest itself, in streetscapes, sculptures, paintings, architectural structures, and more. This illustrated presentation offers illuminating glimpses of mathematics, from Euclidean geometry and normal distributions to Riemann sums and Moebius strips, as seen in a variety of structures and artworks in Washington, D. C., Philadelphia, Toronto, Ottawa, New Orleans, and many other locales. (Received April 22, 2008)

1046-A0-11 **Maria Chudnovsky***, Columbia University, Department of Mathematics, New York, NY. *Perfect graphs—Structure and recognition.*
A graph is called perfect if for every induced subgraph, the size of its largest clique equals the minimum number of colors needed to color its vertices. As it turns out, the notion of perfect graphs generalizes a large number of phenomena, both in graph theory and in combinatorial optimization. Therefore, the problems of charactering perfect (or minimal imperfect) graphs and finding an efficient recognition algorithm have become well known in both communities. In 1960's Claude Berge made a conjecture that any graph with no induced odd cycles of length greater than three or their complements is perfect (thus, odd cycles of length greater than three and their complements are the only minimal imperfect graphs). This conjecture is know as the Strong Perfect Graph Conjecture.

We call graphs containing no induced odd cycles of length greater than three or their complements Berge graphs. A stronger conjecture was made by Conforti, Cornuejols and Vuskovic, that any Berge graph either belongs to one of a few well understood basic classes or has a decomposition that can not occur in a minimal counterexample to Berge's Conjecture. In joint work with Neil Robertson, Paul Seymour and Robin Thomas we were able to prove this conjecture and consequently the Strong Perfect Graph Theorem.

Later, in joint work with G. Cornuejols, X, Lui, P.Seymour and K. Vuskovic, we found an algorithm that tests in polynomial time whether a graph is Berge, and therefore perfect.

In my talk I will give an overview of both these results. (Received April 22, 2008)

1046-A0-12 **Peter Sarnak***, Princeton University, Department of Mathematics, Princeton, NJ. *Integral Appollonian packings and thin orbits.*
An apollonian packing of circles in the plane is integral if the curvatures of all the circles are integers.There are infinitely many distinct such packings and interesting (and mostly difficult)diophantine questions about their curvatures have been raised. We will explain the setup and discuss these questions and give some answers, highlighting the role played by 'small' subgroups of the group of 4 by 4 integer matrices with determinant equal to +1 or -1 . (Received April 22, 2008)

1046-A0-13 **Dan N Rockmore*** (rockmore@math.dartmouth.edu), 6188 Kemeny Hall, Deaprtment of Mathematics, Dartmouth College, Hanover, NH 03755. *Making Math out of Style.*
In today's world, where almost all aspects of life are brought to the common medium of the computer, it is now possible to quantify and extract the style of an artist via computation. One can look to literary, visual, and dance arts and see applications to the problem of authenticating specific artists' and authors' work, as well as to the more general problem of quantifying "style." Taken together, Rockmore's talk will show just how "stylish" mathematics can be! (Received September 16, 2008)

1046-A0-15 **Peter Winkler*** (peter.winkler@dartmouth.edu), Dept. of Mathematics, Kemeny Hall, Dartmouth College, Hanover, NH 03755-3551. *Stacking Bricks and Stoning Crows.*
How far can a stack of n bricks hang over the edge of a table? It took 5 mathematicians—Mike Paterson, Yuval Peres, Mikkel Thorup, Uri Zwick and the speaker—to finally solve (asymptotically) this 150-year-old problem, and the answer is not what most people thought.

We will present a construction (due to Paterson and Zwick) and a curious result about random walk by an invisible object, upon which the upper bound relies. Finally, we will speculate about the precise best way to stack bricks. (Received September 16, 2008)

1046-A0-220 **Michael J. Bardzell***, Salisbury University, Salisbury, MD. *From groups to graphics: Stories of undergraduate research in visualizing abstract mathematics.*

Undergraduate research is becoming an increasingly important component of a student.s mathematics education at colleges and universities across the country. Finding problems that are suitable for undergraduates, yet still offer a true research experience, can be challenging. In this talk we present examples of successful student research from the *PascGalois Project*, which uses colorful computer graphics to generate structures (cellular automata) over finite groups. Many interesting patterns arise which can be understood using concepts from group theory and number theory. Work from several students, as well as two summer one-week student research retreats, will be highlighted. (Received August 20, 2008)

1046-A0-221 **M. Vali Siadat***, Richard J. Daley College, Chicago, IL. *My teaching philosophy and the development of keystone method: A synergistic model for teaching and learning.*

In this talk I will present my teaching philosophy as well as the development of the Keystone model of teaching and learning in mathematics. The Keystone method is a synergistic program which constantly monitors students. progress, varies teaching practices, and uses a set of teaching/learning strategies to address student difficulties. The past results have shown not only dramatic improvement in student outcomes in mathematics, but also in reading comprehension. These results were achieved at no cost to classroom retention. The persistence rates of Keystone students were also higher for the subsequent semesters. (Received August 20, 2008)

1046-A0-222 **David J. Pengelley***, New Mexico State University. *How to beat the lecture/textbook trap! An active classroom via advance student reading and writing.*

I see a vicious cycle: our students don't read the textbook because they know we will lecture on it, and we lecture on the textbook because we know they haven't read it, despite our exhortations. What a waste of precious classroom time; couldn't students be actively engaged in higher level work in the classroom, rather than merely in passive first contact with new material? But how to cut the cycle? Creating an alternative to the typical lecture/textbook paradigm has been my hardest challenge ever in reinventing myself as a teacher. I will explain and show my methods for beating this trap, no matter whether the principal written learning material is a textbook, primary historical sources, or projects. The results? Surprise, my students CAN learn a lot from advance reading, always before first classroom contact with new material, and I can find alternatives to lecturing, but only if I design the process right! (Received August 20, 2008)

Invited Paper Session on Mathematical Sociology

1046-A1-887 **Phillip Bonacich*** (bonacich@soc.ucla.edu), Department of Sociology, University of California, Los Angeles, Los Angeles, CA 90095-1551. *Network Implications of social exchange: an overview.*

Sociologists have developed a variety of mathematical models to describe the networks created by interdependent actors who must cooperate with others. This paper will review some of the more recent models. (Received September 12, 2008)

1046-A1-892 **John Angle*** (angle@inequalityprocess.org), Inequality Process Institute, P. O. Box 429, Cabin John, MD 20818. *A Particle System That Mimics Empirical Income Dynamics.*

The Inequality Process ('inequality' in the sociological sense) was abstracted from an old theory of economic anthropology about why substantial differences of wealth appeared whenever hunter/gatherers acquired a food surplus. Perhaps surprisingly, this stochastic interacting particle system implies a wide variety of statistics of empirical income dynamics at the micro (individual) as well as the macro (distribution) level in industrial societies. The Inequality Process dates from the early 1980's and is similar to an ad hoc modification of the stochastic version of the kinetic theory of gases published in 2000 as econophysics. Since the explanandum of the Inequality Process is much wider and it is grounded in social science, the Inequality Process has replaced the latter particle system as the frontier of the econophysics of wealth and income. (Received September 12, 2008)

1046-A1-893 **Guillermina Jasso*** (gj1@nyu.edu), Department of Sociology, New York University, 295 Lafayette Street, 4th Floor, New York, NY 10012-9605. *Exploring Polarization: the Effects of General Inequality and Subgroup Relative Size on Distance between Subgroups and Dispersion within Subgroups.*

Polarization involves two activities: distance between subgroups increases, and dispersion within subgroups decreases. Two questions that arise concern the effects of the magnitude of inequality and the relative sizes of the subgroups on the two activities of polarization. This paper addresses these questions, analyzing classical probability distributions as well as mixtures of distributions.b (Received September 12, 2008)

1046-A1-895 **Barbara F. Meeker*** (bmeeker@socy.umd.edu), Department of Sociology, University of Maryland, College Park, MD 20742. *Mathematical Models of Talking in Discussion Groups.*

or many years researchers studying face-to-face interaction in small groups have documented a regular process of development of inequality in the amount of talking. Also, persons who talk more have been reliably documented to have more influence on group decisions. This talk surveys a variety of mathematical approaches including Markov chains and dynamical systems that have been applied to this phenomenon. (Received September 12, 2008)

Invited Paper Session on the Beauty and Power of Number Theory

1046-A2-694 **Ken Ono*** (ono@math.wisc.edu), Department of Mathematics, University of Wisconsin, Madison, WI 53706. *Hooks and infinite product power series.*

Infinite product power series play a central role in many areas of number theory. Classical works of Euler, Gauss, and Jacobi are fundamental tools in the subject. Indeed, the Jacobi Triple Product Identity appears prominently in many disciplines: quadratic forms, mathematical physics, the theory of partitions, to name a few. In this lecture we shall discuss a most beautiful identity of Nekrasov and 2006 Fields Medalist Okounkov, and a generalization by Han, which involves partitions and their hooks. We shall discuss some of the applications of these identities in enumerative combinatorics and number theory. (Received September 10, 2008)

1046-A2-697 **George E. Andrews*** (andrews@math.psu.edu), Department of Mathematics, McAllister Bldg., Penn State University, University Park, PA 16802. *Surprises from Ramanujan's Lost Notebook.*

One of the charms of number theory is the unexpected. Often a surprising turn of events reveals both the beauty and the power of number theory. Ramanujan's Lost Notebook is filled with tales of the unexpected disguised as seemingly innocent q-identities. In this talk I shall discuss a few of the surprises in the Lost Notebook that illustrate this phenomenon. These may range from unexpected appearances of arithmetic in quadratic fields to amazing formulas for L.J. Rogers's false theta functions. (Received September 10, 2008)

1046-A2-712 **Mitsuo Kobayashi**, **Paul Pollack** and **Carl Pomerance*** (carl.pomerance@dartmouth.edu), Department of Mathematics, Dartmouth College, Hanover, NH 03755. *Sociable numbers: new developments on an ancient problem.*

Consider iterating the function which sends a natural number to the sum of its proper divisors. A fixed point for this system, such as 6 or 28, is called *perfect*, while a number belonging to a cycle of length 2, such as 220 or 284, is called *amicable*. Known to Euclid and Pythagoras, some scholars have even found allusions to perfect and amicable numbers in the Old Testament. *Sociable* numbers are the natural generalization of perfect and amicable numbers to cycles of arbitrary length—they are mere youngsters, having been studied for only 102 years! This talk will report on some recent results on the distribution of sociable numbers within the natural numbers. (Received September 10, 2008)

1046-A2-727 **Kirsten Eisentraeger***, Department of Mathematics, The Pennsylvania State University, University Park, PA 16802. *Undecidability in number theory.*

In 1900 David Hilbert posed 23 problems to the mathematical community. The tenth problem asked for an algorithm to decide whether an arbitrary polynomial equation with integer coefficients has a solution over the integers. In 1970 Yuri Matiyasevich proved that no such algorithm exists, completing earlier work of Martin Davis, Hilary Putnam, and Julia Robinson.

In this talk I will discuss some aspects of Matiyasevich's proof. I will also talk about related problems, including the analogue of Hilbert's Tenth Problem for equations with coefficients and solutions over the rational numbers. (Received September 10, 2008)

Assessment of Student Learning in Undergraduate Mathematics

1046-A5-137 **Harrison W. Straley*** (straley_harrison@wheatonma.edu), Mathematics and Computer Science Dept., Wheaton College, 26 East Main Street, Norton, MA 02766-2322, and **Lauren Dupee** (dupee_lauren@wheatonma.edu), Mathematics and Computer Science Dept., Wheaton College, 26 East Main Street, Norton, MA 02766-2322. *"Pair-Quizzes": An Instructional and an Evaluative Tool in Mathematics Classes.* Preliminary report.

Some researchers suggest assessment should not only evaluate learning and instruction, but should also be a learning experience. The authors propose an assessment tool that evaluates instructional progress and helps students learn the material. The senior author has, for years, included "pair-quizzes" (cooperative pop quizzes, taken by a pair of students working together for the same grade) as an integral part of his courses. Students pair off with a new partner, approximately every other class, to take a "pair-quiz" over important course material. The "pair-quizzes" are graded, and count for about 3% of each student's course grade. These quizzes have two primary purposes. The first is to help the instructor monitor student progress. Students who do poorly on a pair quiz are encouraged to see the instructor or attend tutoring sessions. If many student-pairs do poorly the content of the "pair-quiz" is re-taught to the entire class. The second goal is to provide an environment where students can teach each other. In these situations both the tutor and the tutee benefit. This paper describes pair-quizzes and their effectiveness in three different mathematics courses: Calculus II, Introductory Statistics, and Mathematics for Elementary Teachers. (Received August 04, 2008)

1046-A5-173 **Samer S Habre*** (shabre@lau.edu.lb), Mme Curie Street, P.O. Box 13-5053, Chouran, Beirut, 1102 2801, Lebanon. *Students' understanding of slope and direction fields in a non-traditional differential equations class.*

A non-traditional introductory course in differential equations emphasizes a qualitative approach to the learning of the material. The recipe-type approach for solving quantitatively first-order differential equations is marginalized; instead such equations are solved by sketching their solutions, either by means of a slope field or through a sketch of the phase line for autonomous equations. Second-order equations are turned into systems of first-order ones; the vector field of the system is then drawn to obtain qualitatively solution curves. Such an approach, whether for single equations or for systems of equations, is based on an understanding of the derivative of a function at a given point. In this presentation, I discuss students' receptivity of this approach when enrolled in a non-traditional differential equations class. In particular, I report on the students' successes and failures when working with slope and vector fields, and I investigate if students understand the differences and similarities between these fields. (Received August 12, 2008)

1046-A5-379 **Xuhui Li*** (xli2@csulb.edu), 1250 Bellflower Blvd, Department of Mathematics, Long Beach, CA 90840. *Designing Benchmarks for Assessing Undergraduate Students' Mathematics Performances in General Education.* Preliminary report.

California State University Long Beach (CSULB) has a highly diverse student population of nearly 38,000. More than one-third of the academic majors require their students to take at least one of the 13 General Education (GE) mathematics courses. Each semester around 100 sections of GE mathematics courses are offered. To re-vision the values and goals of GE, and enforce its cohesion, quality, and sustainability, CSULB is developing student performance benchmarks for each of its four foundation areas, including mathematics.

This presentation focuses on a set of newly drafted benchmarks for assessing student achievements in GE mathematics. The benchmarks encompass six major expected learning outcomes: 1. Recalling and performing technical skills; 2. Recognizing mathematical structures for further study of mathematics; 3. Recognizing mathematical structures arising outside mathematics classrooms; 4. Organizing and analyzing data; 5. Synthesizing ideas and generating questions; and 6. Evaluating and critiquing information, statements, arguments, and reasoning.

The presenter will provide a detailed description for each learning outcome, summarize campus-wide responses to the draft benchmark, and report the on-going design of pilot assessment items and rubrics. (Received August 29, 2008)

1046-A5-400 **Ronald M. Brzenk*** (brzenkr@hartwick.edu), Hartwick College, Department of Mathematics, Oneonta, NY 13820. *Outcomes Based Assessment of Student Learning in Mathematics.* Preliminary report.

This paper will describe procedures used to assess student learning by Mathematics majors at Hartwick College, a liberal arts college in Oneonta NY. The intended student learning outcomes, the associated assessment methods, and assessment rubrics will be presented. (Received August 31, 2008)

1046-A5-1067 **Jerry Obiekwe*** (Accessx@uakron.edu), P. O. Box 411, Orrville, OH 44667. *An Examination of the Mathematics and Technology Attitude Scale(MTAS): Implication to Assessment of Undergraduate Mathematics.*

Although course level assessment could have different definitions from one discipline to another, but in a convergent subject like mathematics, it means the evaluation of the proficiency level of students in the course learning objectives. One approach to accomplish this task is to test students on mathematical concepts relating to the learning objectives. Alternatively is to assess student evolvement in certain affective variables that affect the learning of mathematics. It has been suggested in the literature to give equal deference to cognitive and affective dimensions in the teaching and learning process of mathematics because some of the problems that may be holding back some students from academic success may lie in the affective domain. Mathematics and Technology Attitude Scale(MTAS) is an instrument designed and validated in Australia to measure certain affective variables that can affect the learning of mathematics. MTAS has five dimensions. The purpose of this study is to investigate the psychometric characteristics of MTAS using American college students in hopes of replicating what has already been done in Australia. The results of this study and its implications to teaching and learning especially in the assessment of college algebra will be presented. (Received September 14, 2008)

1046-A5-1131 **Karla Marie Childs*** (kchilds@pittstate.edu), 110 Woodmont Drive, Joplin, MO 64801. *Basic Skills Exam in College Algebra.*

The Basic Skills Exam is an important formal assessment tool used in college algebra at Pittsburg State University. The skills tested on the Basic Skills Exam were determined by the department to be necessary for success in the mathematics courses for which college algebra is a prerequisite. Every student from every section of college algebra at PSU must demonstrate mastery of these basic algebra skills in order to successfully exit the course. (Received September 14, 2008)

1046-A5-1346 **J Winston Crawley*** (jwcraw@ship.edu), Shippensburg University, 1871 Old Main Dr., Shippensburg, PA 17257, and **James E Hamblin**, Shippensburg University, 1871 Old Main Dr., Shippensburg, PA 17257. *Assessment Across the Curriculum; Varying Strategies for Varying Situations.*

In this talk we address a bit of the history of assessment by the Department of Mathematics at Shippensburg University, with an emphasis on the present status of that effort. Included in the talk are some lessons we have learned, both from our successes and from our failures. A major emphasis is our gradual movement to an all-encompassing framework for assessment, but with varying strategies for differing audiences: math majors; general education students in a large variety of different courses; and developmental students. We focus also on the interface between our general assessment plan for math majors and our more broad-based assessment for math education majors, developed in conjunction with a recent NCATE review. (Received September 15, 2008)

1046-A5-1347 **Sarah V. Cook*** (sarah.cook@washburn.edu). *Calculus Assessment: Then and Now.* Preliminary report.

Since 2003, Washburn University has been using a pre/post test assessment method in the calculus sequence. In this session, we will look back at what we have learned from this assessment practice. We will also discuss recent changes to the exams for Calculus II and III and the factors that motivated these changes. (Received September 15, 2008)

1046-A5-1615 **Rich West*** (rwest@fmarion.edu), Department Of Mathematics, Francis Marion University, PO Box 100547, Florence, SC 29501. *Portfolio Assessment of General Education Mathematics.* Preliminary report.

Having used portfolios now for over fifteen years, I have found them to be a valuable instrument for assessment of student learning, program assessment and most recently general education mathematics. In this talk I will outline a two course college algebra sequence and the assessment plan we use to assess student learning. Included in this plan are portfolios. This two course algebra sequence satisfies the general education requirements in mathematics for most non-science majors. In designing the two course college algebra sequence, we established ten goals for student learning. For the last three years, I have assessed these courses by using stratified sampling and review of the course portfolios for input into the department's institutional effectiveness report. The department has found this assessment valuable to inform program design and structure changes. Last year the university institutional research folks requested quantitative data to compare years. I chose to continue the portfolio assessment and utilize a six point scale for assessing the ten course goals. I have three semester's results which I will address from three perspectives: student learning, program assessment, and institutional general education. (Received September 16, 2008)

1046-A5-1759 **Melvin A Nyman*** (nyman@alma.edu), Department of Mathematics & Computer Science, Alma College, 614 W. Superior St., Alma, MI 48801, and **Robert Molina** (molina@alma.edu), Department of Mathematics & Computer Science, Alma College, 614 W. Superior St., Alma, MI 48801. *Assessment of the undergraduate mathematics program.*

Regional accrediting agencies are insisting a serious assessment of college and university academic programs. We will report on the evolving assessment program for undergraduate mathematics at Alma College. Our approach is multi-layered. We use the Major Field Test as an external validator. Seniors demomstrate their ability to do mathematics by undetaking a small capstone project which requires both written and oral components. We are also developing several rubrics for faculty to comment on student preparation from prerequisite courses as well as for assessing the quality of the written and oral presentations. (Received September 16, 2008)

1046-A5-1806 **george rublein*** (gtrubl@math.wm.edu), Department of Mathematics, College of William and Mary, Williamsburg, VA 23187-8795. *A Control versus treatment evaluation of the chemistry in calculus project at William and Mary.*

Incoming freshman at William and Mary are assumed to have taken high-school chemistry. With the support of an NSF CCLI grant, a collection of problems for first and second semester calculus students was developed to exploit this acquaintance with the vocabulary of chemistry. Students entering in the Fall 0f 2006 were the first to be exposed to these problems This term, Fall 2008, a number of the students who did calculus with these chemistry exercises are taking the first course in physical chemistry. Those students share the class with a somewhat larger group of students who took calculus elsewhere, either by transfer or by AP credit. With the cooperation of our co-PI, who is teaching the P-chem course, we will report on evidence, measured or informal, to learn whether the chemistry in calculus project was an advantage to students in physical chemistry. (Received September 16, 2008)

1046-A5-1820 **Milo Schield*** (schield@augsburg.edu), Dept. of Business Administration, 2211 Riverside Drive, Augsburg College, Minneapolis, MN 55454. *Assessing Quantitative Literacy Using a Wide Range of News Stories.* Preliminary report.

Assessing a student's Quantitative Literacy (QL) level based on their analysis of the numbers in the news is highly desirable since QL emphasizes numbers in context. Given the importance of context in such stories, such an assessment can be a complex and difficult task. Schield (2008) presents a critical thinking template for analyzing those news stories that used numbers as evidence for non-numerical conclusions. This ten-section template also provides a way to assess students on their analysis of such studies in the news. This paper investigates the range of news stories that can be handled by this ten-part critical thinking template. These news articles include medical tests, surveys, charts, graphs, tables, forecasts/projections, claim-based studies and experiments as well as stock prices, sports scores and bridge hands. These articles range in length from short sound-bites to detailed research reports. This paper addresses the question of why use a template designed for a wide range of articles, when many articles need only a part of that template – and may need that part in far more detail. (Received September 16, 2008)

1046-A5-1848 **Heather Coughlin*** (hcoughlin@csustan.edu), Department of Mathematics, California State University, Stanislaus, One University Circle, Turlock, CA 95382. *Assessment working instead of working for assessment.* Preliminary report.

California State University, Stanislaus has completed 2.5 years of university-wide formal program assessment. This talk will focus on the development of the assessment structure created by the mathematics department and how it fits into the university's plan. In particular I will discuss the successes and challenges faced by the mathematics department as it created a plan which formalized and extended the casual procedures already in place. I will discuss the assessment tools we have used, how our program has changed, and the next steps, including researching the necessity of a calculus readiness screening exam and how such readiness relates to our student learning objectives. (Received September 16, 2008)

1046-A5-1875 **Joy Moore*** (moorej12@xavier.edu), 112 Hinkle Hall, Mail Location 4441, Xavier University, Cincinnati, OH 45207-4441. *Challenges of Assessing Mathematics Content Courses Designed Specifically for Middle Childhood Education Majors.* Preliminary report.

Despite the call for an increase in mathematics content knowledge among preservice middle childhood mathematics teachers, most research studies investigate professional development experiences in mathematics for inservice teachers. As mathematics departments invest in course development and mathematics education faculty, assessing the impact of mathematics content courses on middle childhood preservice teachers is of great importance. In 2005, Xavier University mathematics faculty developed Foundations of Arithmetic, Geometry and Measurement, Algebra Concepts, and Math Problem Solving specifically for the Middle Childhood Mathematics Education Program. In 2008, an interdisciplinary team of three Xavier faculty members were awarded a grant to evaluate the impact of the new mathematics curriculum for Middle Childhood Education majors. What effect has the newly developed middle childhood mathematics courses had on the content knowledge and self efficacy of the preservice middle childhood mathematics candidates? This paper will present preliminary data analysis and a discussion of the challenges in implementing appropriate assessment of the courses. (Received September 16, 2008)

1046-A5-1884 **Michael D. Bice*** (mbice@csustan.edu), Mathematics Department, California State University, Stanislaus, 1 University Circle, Turlock, CA 95382. *Evolution of a Capstone Course for Prospective High School Mathematics Teachers.* Preliminary report.

Since the early 1990s, the California Commission on Teacher Credentialing has set forth statewide standards for single subject matter programs that prospective teachers complete to demonstrate competency. As one part of its Subject Matter Preparation Program in Mathematics, the Mathematics Department at California State University, Stanislaus, offers a capstone course entitled *Senior Seminar in Mathematics*. This class provides students with experience in mathematical communication in oral and written forms. Students write and present papers about problem solving techniques at various levels of mathematics education, mathematical theorems and proofs from upper-division topics, and critiques of journal articles about mathematics education. In this session, I will share my department's experiences with this course, including the materials used, the student feedback we received, and recently implemented changes to the class designed to enhance student learning. (Received September 16, 2008)

Building Diversity in Advanced Mathematics: Models that Work

1046-B1-957 **Y. Kathy Lin*** (ywklin@gmail.com). *Factors impacting the pursuit of mathematics for female PhD students.*

One approach to increasing the number of women in advanced mathematics is by understanding what has worked for successful women; such an understanding could contribute to the development of programs and experiences which can help women to want to and be able to pursue advanced mathematics. This qualitative study examined the factors that six women in a top-ranked mathematics PhD program believe have motivated and enabled them to pursue mathematics. Analysis of in-depth interviews with these women found that most women had a combination of personal communities, academic communities, and academic experiences which influenced their pursuit of mathematics. Each of these categories impacted the women in several ways. For example, most of the women felt that academic communities provided them with not only academic support, but also like-minded peers who validated their interests, inside information about the experiences top mathematics students are expected to have, and exposure to older students and mathematicians whose day-to-day lives helped the women understand what it means to be a mathematician both personally and professionally. These results and others will be discussed, with an emphasis on replicable experiences which the women found to be particularly influential. (Received September 13, 2008)

1046-B1-1108 **Debbie Gochenaur*** (gochenaurd@etown.edu), Elizabethtown College, Math Department, One Alpha Drive, Elizabethtown, PA 17022. *Evaluating STEM Intervention Programs.*

As the United States science, technology, engineering, and mathematics (STEM) workforce continues to grow faster than the overall workforce, the need for college-trained STEM workers continues to increase; moreover, the percentage of African Americans in these positions also needs to rise. Numerous intervention programs, geared towards increasing the number of underrepresented minorities in STEM, were developed to increase undergraduate retention and attainment rates, graduate degree attainment rates, and the rate at which students were entering the STEM workforce. Although many of these programs have conducted small self-studies, few have undergone extensive external program evaluation. As millions of dollars continue to pour into these programs, evaluation of their effectiveness at increasing the numbers of African Americans in STEM needs to be addressed. Specifically, program components that contribute more towards increasing those numbers need to be identified. An evaluation model that uses qualitative analysis to build upon a quantitative analysis base, utilizing logistic regression, will be explored. (Received September 14, 2008)

1046-B1-1708 **Martin V Bonsangue*** (mbonsangue@fullerton.edu), Martin V Bonsangue, Dept. of Mathematics, Fullerton, CA 92834, and **David E Drew** (david.drew@cgu.edu), David E Drew, The Claremont Graduate University, Claremont, CA 91711. *Effecting Systemic Change in the University: Five-Year Results from the NSF Houston-Louis Stokes Alliance for Minority Participation.*

This session summarizes the activities and results of Phase I the Houston Louis Stokes Alliance for Minority Participation. The original proposal for support under the NSF L-SAMP Program focused on one primary goal, namely, to double the number of under-represented minority students receiving bachelor's degrees in science, technology, engineering, and mathematics (STEM) majors in five years. The data for Phase I show that this goal has been nearly realized in the Houston project. The H-LSAMP came within 5 percent of achieving the goal of doubling the total number of STEM degrees awarded to minority students during Phase I. These results indicate that participating institutions have been successful at both recruiting and retaining minority students in its STEM majors, including mathematics. Moreover, Phase I data show a marked increase in the number of H-LSAMP students who have gone on to advanced degrees over the past five years. In addition, there is an increase in the number of students successfully matriculating from the two-year colleges and making timely progress towards degree completion. These results also imply that participating institutions have developed and implemented successful approaches to supporting minority student achievement. (Received September 16, 2008)

1046-B1-1787 **Patricia L Hale*** (phale@csupomona.edu), Dept. of Mathematics and Statistics, 3801 W Temple AVE, Pomona, CA 91768. *The Implementation and Impact of an ADVANCE IT Grant at a Primarily Undergraduate Institution.* Preliminary report.

The NSF funded ADVANCE Institutional Transformation Grants are awarded to institutions to improve the climate for, and advance the careers of, female faculty in Science, Engineering, Technology and Mathematics. Most of these grants have been awarded to Research-1 Institutions. This talk will present key factors that led to a Primarily Undergraduate Institution (PUI), Cal Poly Pomona, receiving award of such a grant as well as the some of the difficulties and success in implementation. (Received September 16, 2008)

1046-B1-1913 **Helmut Knaust*** (hknaust@utep.edu), Department of Mathematical Sciences, UTEP, El Paso, TX 79968-0514, and **Emil D. Schwab** (eschwab@utep.edu), Department of Mathematical Sciences, UTEP, El Paso, TX 79968-0514. *Modular Delivery and Peer-Led Team-Learning for Precalculus.* Preliminary report.

The University of Texas at El Paso, located in the largest bi-national community along the US-Mexico border, is the only comprehensive university within reach for a growing population of local college students, the majority of whom are Hispanic. The Department of Mathematics has a long tradition of delivering nearly all of its combined five credit-hour College Algebra/Precalculus and four credit-hour Calculus I sections in a modular format. Building on this we recently joined a college-wide NSF-sponsored initiative to make peer-led team-learning (PLTL) activities a substantial component of all its freshmen-level physical sciences and mathematics courses (Introduction to Chemistry, Introduction to Physics, Precalculus). According to the *Theory of Validation* (L. Rendón) PLTL activities should be an excellent instrument to engage minority students in their learning and further their academic development. Consequently we expect the project to have a significant positive impact on student retention and student success in the early years of undergraduate STEM education. The presentation will introduce in detail the concept, organization and practice of modular course delivery and the accompanying PLTL workshops; we will also present preliminary results of our experiment. (Received September 16, 2008)

College Algebra: Focusing on Conceptual Understanding, Real-World Data and Mathematical Modeling

1046-C1-29 **Kimberly Muller*** (kmuller@lssu.edu), 650 W. Easterday Ave., Department of Mathematics and Computer Scienc, Lake Superior State University, Sault Ste. Marie, MI 49783. *Revitalizing College Algebra: A Success Story.* Preliminary report.

Changes in curriculum and pedagogy of traditional courses can be difficult tasks, even for educators at large universities with abundant resources. At small universities, it can be a daunting task to make drastic changes without the necessary budget for training. Administrative and faculty support are essential. Luckily, integrating applications into a college algebra course provides an excellent way to help students make connections between mathematics and other disciplines. It is also an ideal platform for supporting university initiatives such as an administrative call for quantitative literacy or writing across the curriculum. Application problems can also be easily introduced using a variety of teaching techniques, both traditional and non-traditional. All of these aspects make it easier to obtain support. Due to limited class sizes, small universities can often provide more opportunities to use applications to promote a student-centered learning environment. Our department has been successful at finding the needed training and resources. We have also drastically improved our student success rates in college algebra without harming subsequent courses. Ideas regarding implementation and assessment will be discussed. (Received June 13, 2008)

1046-C1-164 **Murray H. Siegel*** (murray.siegel@centralaz.edu), 20159 N Geyser Drive, Maricopa, AZ 85238. *A Data-Based Project to Enhance the Teaching of Functions in College Algebra.*

For many college algebra students algebraic functions are irrelevant. They have seen these functions in previous classes but must struggle to learn the material again. Using linear, piece-wise defined, quadratic, cubic, exponential and logarithmic functions to model real data allows the student to see the importance of these functions. A project where each student finds data drawn from an area of interest (such as politics, sports, food or entertainment) is the culminating activity for this course. Students must manipulate the coefficients for the various functions to find the best model for each type and then choose the very best model. In the project report the student must explain why the "best" model makes sense. The student relates his/her interest in the data to the nature of the specific function. Two examples will be provided from reports from previous students. One demonstrates the quadratic relationship between hits and runs scored for Major League Baseball players. The second validates that an exponential function best models the relationship between the height and the average digs per match for NCAA Division 1 volleyball players. (Received August 08, 2008)

1046-C1-175 **Sheldon P. Gordon*** (gordonsp@farmingdale.edu), Department of Applied Mathematics, Farmingdale State College, Farmingdale, NY 11731. *Getting Students to DIGMath: Dynamic Interactive Graphics in College Algebra.*

The presenter has developed a comprehensive set of DIGMath modules in Excel that allow faculty and students to investigate virtually every topic in College Algebra and related courses in an exploratory way. Topics include linear functions, behavior of exponential functions, doubling time and half-life, power functions, fitting functions to data, quadratic functions, cubic functions, polynomial functions, shifting and stretching functions, discovering sinusoidal functions, fitting sinusoidal functions to data, approximating sinusoidals with polynomials, systems of linear equations, and matrix models. In each case, the explorations allow the students to see in real time the effects of changing any of the associated parameters (using sliders) to gain a much deeper understanding of the underlying concepts than can be achieved with paper and pencil or even a graphing calculator. The use of these modules helps change the focus in the course to an emphasis on conceptual understanding and math modeling rather than on algebraic manipulation, as called for in all the reports and recommendations for a modern course in College Algebra that serves the needs of today's students. All of these modules can be downloaded from the presenter's website, farmingdale.edu/ gordonsp. (Received August 12, 2008)

1046-C1-180 **Jacqueline Brannon Giles*** (jbgiles@yahoo.com), 13103 Balarama Drive, Houston, TX 77099. *News Ways to compare NFL players, using Model Building.*

An adaptation of a calculus project allows precalculus students to use a new way to compare NFL wide receivers. Model building will be demonstrated, and the same analysis will be conducted using rectangles and trapezoids.

Calculus students analyzed a quantitative analysis comparing the career statistics of Jerry Rice and Warren Wells. They created a model for each player by graphing a piecewise defined function connecting ranks and then used integration to find the area under the piecewise linear curves. Similarly, precalculus studenta will use the same data, but the areas will be computed for rectangles and trapezoids. The results inspired a question. The students asked, "Why hasn't Wells been considered as a nominee to the Hall of Fame since he ranks No. 1 in two of the seven categories in the quantitative study?" Wells, for example, has ranked No. 1 in two categories for about 38 years, indicating that the numbers tell a story and that some players statistics have stood the test of time.

The graphs give a clear picture of the strengths and weaknesses of each wide receiver, pointing out that cumulative data is not always sensitive to the strength of a player in a subcategory. This method allows for more insight in a comparative study. (Received August 13, 2008)

1046-C1-319 **Lisa S. Yocco*** (lisay@georgiasouthern.edu), Department of Mathematical Sciences, P.O. Box 8093, Statesboro, GA 30460. *Social Science Applications in an Applied College Algebra Course.*

One of the biggest challenges in teaching college algebra is convincing non-science and non-engineering students that algebra is important in their future studies and careers. One solution to this is the development of an algebra course based on real life applications in a setting that connects mathematical content with the real world. In addition to applications in management and life sciences, applications related to the social sciences are emphasized. These applications, which include population growth, the normal curve for IQ, life span, poverty threshold, global warming, cohabiting households, SAT scores, Internet use, and spread of a disease, show students that there is a connection between mathematics and their world. These and other applications can be used with data analysis, modeling, and technology so that the approach is refreshing and interesting to the students. For example, when discussing linear functions, the connection between the slopes of the graphs and the rates of change of the functions permits us to ask much more interesting questions. Creating functions that model real data and solving equations that are modeled or related to real data is more meaningful and satisfying than "working" skill exercises with no apparent application. (Received August 26, 2008)

1046-C1-408 **Suzanne I Dorée*** (doree@augsburg.edu), Mathematics Department, Augsburg College, 2211 Riverside Avenue, Minneapolis, MN 55454. *"I'd rather be approximately right than precisely wrong": moving beyond mathematicians' natural obsession with the exact in college algebra.* Preliminary report.

Too much of what we teach in a traditional college algebra course is based on our obsession with exact answers. But realistic problems based on real data are, at best, approximate by their nature. In such settings, not only are graphical and numerical methods now sufficient, but how we work symbolically must change as well. This talk will give concrete examples of solving linear, quadratic, and exponential equations when the goal a good approximation of the solution. This work is based on our 14-year record of teaching a highly successful, 100% contextual, modeling-based "Applied Algebra" course to diverse learners. (Received September 01, 2008)

1046-C1-723 **Marko Kranjc*** (M-Kranjc@wiu.edu), Department of Mathematics, 1 University Circle, Macomb, IL 61455. *Mathematical readiness of incoming college freshmen.*

Math readiness of incoming freshmen will be examined. For the last four years the author has been in charge of math placement for all freshmen at his university. In Fall 06 and Spring 07 he administered an anonymous quiz on basic skills to over 950 students. Both his math placement experiences and the quiz results suggest that it may be time to re-examine how students are prepared for college and how colleges deal with the problem. The results of the 2005-2006 ACT National Curriculum Survey also seem to suggest that a critical look at present practices may be necessary.

Based on the math placement outcomes and the quiz results we will look at some present practices and try to examine their strengths and weaknesses. We are interested both in K-12 preparation and in the way colleges deal with underprepared students, especially in algebra based lower division courses. (Received September 10, 2008)

1046-C1-1136 **June I. Decker*** (jdecker@trcc.commnet.edu), Three Rivers Community College, New London Turnpike, Norwich, CT 06360. *A math teacher sees the light: Photonics labs in an algebra class.* Preliminary report.

The presenter will discuss her experience teaching intermediate algebra infused with examples from engineering technology. In 2007, Three Rivers Community College formed a Technology Learning Community (TLC) student cohort funded by an ATE/NSF grant. Among the program's features is interdisciplinary teaching and learning among the first semester English, Technology and Mathematics courses. In preparation for teaching the course, the presenter attended a weeklong Problem Based Learning Workshop (PBL), also funded by an ATE/NSF grant whose purpose is to develop and disseminate industry-driven problem-based learning challenges for secondary and postsecondary institutions. The presenter collaborated with a photonics professor to do two labs with the students. The first lab focuses on discovering the inverse square law and understanding irradiance by fitting curves to data that is gathered. An exponential function is illustrated by the second lesson that collects data on the amount of light passing through different numbers of filters. The presenter will discuss the benefits of working with a scientist, the importance of support staff in working with cohort groups, and the success rates of the cohort group in subsequent courses. (Received September 14, 2008)

1046-C1-1146 **Joyati Debnath*** (JDebnath@winona.edu), 301 Gildmeister Hall, Mathematics and Statistics, Winona State University, Winona, MN 55987. *Involving Students in Conceptual Learning in College Algebra and Pre-Calculus.*

This talk will address several issues related to College Algebra and Pre-Calculus courses at Winona State University and how and what different changes are made to ensure the success of students' conceptual learning. Course offerings are changed, content/syllabus revised and faculty discussions promoted among several sections to ensure consistency. Emphasis is put more on conceptual understanding via real world problems and mathematical modeling instead of dry drills on algebraic manipulations as done in traditional courses. Observations made that the students seem to connect more easily to mathematical concepts when attached to real world applications. (Received September 14, 2008)

1046-C1-1276 **J F McGowan*** (jmcgowan@howard.edu), 407 Gilmoure Dr., Silver Spring, MD 20901. *Implementation of Refocused College Algebra at Howard University.*

I will give an interim report on a program to refocus college algebra at Howard University. Since fall 2006, several sections of college algebra 1 at Howard University have been set aside each semester to experiment with a new pedagogy involving group projects and applied problems. In spite of recurring problems and institutional inflexibility, this new pedagogy shows some promise. Not only have GPAs in the experimental sections been higher than those in the traditional sections, but students have expressed more satisfaction with the experimental teaching method. In addition, their scores on the multiple choice sections of the final exam were higher than those of other students. (Received September 15, 2008)

1046-C1-1417 **Jennifer J. Kosiak*** (kosiak.jenn@uwlax.edu), Mathematics Department, 1020 Cowley Hall, 1725 State Street, La Crosse, WI 54601, and **Jon Hasenbank** (hasenban.jon@uwlax.edu), Mathematics Department, 1020 Cowley Hall, 1725 State Street, La Crosse, WI 54601. *Focusing on Algebraic Understanding using a Student-Centered Questioning Framework.*

A recent report indicated that nearly one in four high school graduates do not possess the necessary prerequisite skills for success in college-level mathematics courses (NCES, 2001). As a direct consequence, undergraduate students who have not developed sufficiently deep understanding of mathematics procedures find themselves struggling in their mathematics courses that depend on solid algebra skills. This session will examine the effectiveness of refocusing instruction based upon a student-centered framework designed to help students develop deep and well-connected knowledge of procedures. As part of a larger teaching and learning project, a series of activities and assessments for two algebra-intensive courses (College Algebra and Math for Elementary Teachers II) were developed and implemented. These materials were used as part of a quasi-experimental design to collect evidence on improvements in student procedural skill and procedural understanding. The development of these activities, implementation issues, and the results in terms of student performance will be discussed. (Received September 15, 2008)

1046-C1-1478 **Erick B Hofacker*** (Erick.B.Hofacker@uwrf.edu), 214 C North Hall, River Falls, WI 54022, and **Kathryn Ernie** (kathryn.t.ernie@uwrf.edu), 206E North Hall, River Falls, WI 54022. *Infusing Real-Life Opportunities, Questions, and Concepts into the Mathematics Curriculum.*

The authors will present real-world based problems they have developed and used in their general education mathematics courses (College Algebra, College Trigonometry, Pre Calculus, Liberal Arts Mathematics, etc.). Problems will focus on using real-life data (changes in gasoline prices) as well as real-life scenarios (gambling games and tourism) which students can relate to while learning the mathematical concepts being taught in their courses.

The authors will discuss how they use these types of problems to assist in modifying their curriculum so it puts a greater emphasis on concepts and modeling of scenarios, rather than manipulation skills and recollection of facts. The authors will give suggestions for sources of inspiration where problems can be developed, and how they use these sources to add new questions into their curriculum.

The paper will conclude with a brief discussion of how the use of i-clickers in these classes has assisted the authors in refocusing these courses so their students place a greater value on conceptual understanding, communication, and representation. (Received September 15, 2008)

1046-C1-1641 **Rich West*** (rwest@fmarion.edu), Department Of Mathematics, Francis Marion University, PO Box 100547, Florence, SC 29501. *Three Interesting Projects for College Algebra.*

In designing a new two-course college algebra sequence for our non-science majors, we have found that projects generate the most interest, effort and learning by the students. In this talk after a quick outline of the courses and the assessment plan, I will address three projects that we have used successfully in our courses. Linear programming, linear systems, and conic sections are topics that are sometimes considered optional in a college algebra sequence. Utilizing projects we make these topics important vehicles to learning. I will cover three projects in enough detail that they could easily be integrated into an existing course or added as extra homework assignments. I will also address options for the use of these projects in and outside the classroom. (Received September 16, 2008)

1046-C1-1681 **Victor J. Donnay*** (vdonnay@brynmawr.edu), Department of Mathematics, Bryn Mawr College, 101 N. Merion Ave., Bryn Mawr, PA 19010. *How mathematics can contribute to solving the problems facing the world; Building civic engagement into mathematics courses as a way to motivate and inspire students.*

"What are some problems facing the world today?"

This provocative question has become the standard opening gambit in my math courses. Students' responses include: climate change, terrorism, HIV/AIDS, Asian flu, energy dependence, overpopulation, animal extinctions and pollution. Just when the students are beginning to wonder what this has to do with math, I deliver the zinger. The goal of our course is to see how the mathematics we will be learning can be used to address (some of) these issues. There are audible gasps from the students. I have them hooked.

In his book What the Best College Teachers Do, Ken Bain observes that highly successful teachers often start out their courses by painting the broadest possible picture of the importance of what they are going to teach so as to stimulate student interest and motivation. Once students are interested and motivated, they will be more successful at learning. As we work to redesign College Algebra, and other courses, let us consider incorporating this tactic.

I will illustrate this approach by showing how the mathematics of linear and exponential functions can be linked to issues of climate change, caused by increasing CO2 concentration, and to the genocide in Rwanda, to which over-population contributed. (Received September 16, 2008)

1046-C1-1745 **Alice Eiko Pierce*** (alice.pierce@gpc.edu), 555 North Indian Creek Drive, Clarkston, GA 30021, and **Ray E. Collings** (ray.collings@gpc.edu), 555 North Indian Creek Drive, Clarkston, GA 30021. *Elementary Modeling Across the Two-Year College Curriculum.*

Elementary modeling has revitalized the teaching and curriculum choices since 1997 for many Georgia Perimeter College mathematics students and faculty. Experiences in real-world data use particularly in the two courses of Introduction to Mathematical Modeling and College Algebra will be the session foci. Anecdotal evidence of effects modeling has had in other courses will also be shared. (Received September 16, 2008)

1046-C1-1800 **Stephanie Bowers*** (bowerss@math.oregonstate.edu), Department of Mathematics, 368 Kidder Hall, Oregon State University, Corvallis, OR 97331, and **Barbara E Edwards**, **Charisse Hake**, **Gulden Karakok** and **Ching-chia Ko**. *Students' Conceptual Understanding and Attitudes in an Activity-Based Modeling Approach to Teaching College Algebra.*

The pupose of this talk is to describe the attitudes of students toward an experimental activity-based modeling college algebra course. The design of the course was based upon results from mathematics education research on student understanding of the concept of function and on a theory that mathematical understanding develops over time as students engage in meaningful and relevant mathematical activity. We taught the first pilot sections in Fall 2006 and have revised the curriculum over the last two years based upon the experiences of both instructors and students in the course. This talk will describe the course and give some of the current research results. (Received September 16, 2008)

1046-C1-1808 **Barbara E Edwards*** (edwards@math.oregonstate.edu), Department of Mathematics, Oregon State University, 368 Kidder Hall, Corvallis, OR 97331. *Changing the Culture: Professional Development for an Activity-Based Modeling Approach to Teaching College Algebra.*

The CRAFTY Guidelines for College Algebra suggest new approaches in the teaching of College Algebra – both pedagogical and content changes. Mathematics education research shows that change occurs slowly and over time. What implications does this have when new curriculum requires significant changes in an instructor's approach to teaching a course? This talk will describe recent work in professional development at the author's own institution as well as more broadly with instructors involved in a recent national college algebra project. (Received September 16, 2008)

1046-C1-1816 **Michael T Catalano*** (micatala@dwu.edu), 1200 University Ave. W., Mitchell, SD 57301. *College Algebra in Context: A Learner-centered Approach Incorporating Data-driven Activities Related to Social Issues.*

A report on a National Science Foundation CCLI-EMD project (DUE #0442979) supporting the development and implementation of a learner-centered, inquiry-intensive, data-driven, activity-oriented college algebra course, incorporating realistic problem situations emphasizing social and economic issues, including hunger and poverty, energy, and the environment. The project is nearing completion and seeks to address two national needs, namely a need for U.S. citizens with a greater level of quantitative literacy, and a need for improved mathematics education for K-12 teachers. The project supports the mission of the McGovern Center for Leadership and Public Service. Materials will be available for those interested in offering pilot sections in the fall of 2009. (Received September 16, 2008)

1046-C1-1858 **Bill Haver*** (whaver@vcu.edu) and **Kim Shannon**. *Teaching Modeling College Algebra for 2000 students: Garnering support from Faculty and Administrators.*

Beginning in 2008, Virginia Commonwealth University is offering all sections of College Algebra using a modeling approach. Approximately 2000 students enroll in College Algebra each year. We have adopted the MAA College Algebra Guidelines and its Course Goals, Competencies, Emphasis in Pedagogy, and Assessment. Before the decision was made to offer all sections of the course following the Guidelines we piloted the modeling course for four years. During the first two years the students did not know which approach they were registering for. The large majority of the instructors were very favorable about the approach and thought that the students learned more. The faculty, and particularly the university administration, supported the decision to offer all sections of the course in this format partially on the basis that the DFW rate has been significantly lower in the modeling sections and student success rate (for the much larger percentage of students who took the following courses) has been at least as high in subsequent courses. The administration has provided financial support to limit class size to 32 and to hire an undergraduate student assistant for each section, enabling instructors to teach the course in the spirit of the Guidelines. (Received September 16, 2008)

1046-C1-1862 **Ed Eades*** (eoeades@vcu.edu) and **Bill Haver** (whaver@vcu.edu). *Teaching Modeling College Algebra for 2000 students: Providing Professional Development and Course Materials for Instructors.*

Beginning in 2008, Virginia Commonwealth University is offering all sections of College Algebra using a modeling approach and taught following the MAA College Algebra Guidelines. The materials that we have adopted, the supplemental materials we have developed, and the approaches that we expect the instructors to take require a major departure from current practice for most of the instructors of this course. Most of the sections are taught by adjunct instructors and graduate teaching assistants. In order to support the instructors we held a two-day Workshop before the semester and weekly hour long planning sessions for all instructors and a two-day Workshop in October to continue and expand this support. The presentation will include a description of the course materials, the two workshops and the weekly planning sessions. (Received September 16, 2008)

1046-C1-1878 **Paula Shorter*** (paula.shorter@rockhurst.edu), Math and Physics Dept., Rockhurst University, 1100 Rockhurst Road, Kansas City, MO 64110, and **Mairead Greene** and **Zdenka Guadarrama**. *Engaging Precalculus Students in the Complete Process of Mathematical Modeling.*

From the initial development of well-formed questions in the context of a larger investigation, to finding real data, building mathematical models and making predictions, students in our precalculus course build a deep understanding of the purpose and process of mathematical modeling through a multi-stage, semester-long modeling project. Students choose their own topic to investigate and locate their own real data. We use our university first-year theme (this year it was "Stewardship of the Earth") to focus their choice of topics and to strengthen their connection with the project by making it a more integral part of their first year learning experience. Students gradually build independence in modeling via relevant course activities that provide less and less guidance as the semester progresses. Also included in this presentation will be preliminary results of ongoing studies in our department over multiple sections of precalculus on student learning and performance, student attitudes, and student population data. (Received September 16, 2008)

1046-C1-1879 **Wendiann R Sethi*** (sethiwen@shu.edu), 400 South Orange Ave, Dept. of Mathematics and Computer Science, South Orange, NJ 07079. *Technology driven investigations for Intermediate Algebra for Business Majors.*

We have found that using technology driven investigations allow students to understand the three forms that functions can be represented in an easy way. Functions can be shown as tables, graphs and equations. With the use of graphing calculators, Excel and Maple, student work through various tasks to learn the nature of the mathematical models that are created by these functions. Students enjoy these in class activities and work well in small groups to find the answers to the questions. This talk will show examples for the graphing calculator, Excel and Maple that are used in our new class of Intermediate Algebra/College Algebra for business majors. (Received September 16, 2008)

1046-C1-1941 **Xuhui Li*** (xli2@csulb.edu), 1250 Bellflower Blvd, Department of Mathematics, California State University - Long Beach, Long Beach, CA 90840. *Make College Algebra More Meaningful for Non-Calculus-Bound Majors.*

In Fall 2007 the math department at California State University – Long Beach started to offer MATH 109, Modeling with Algebra, as the last General Education math requirement for social science majors, health professionals and others that use algebraic language at a moderately technical level. The main goal is to provide an exposure to the usefulness of algebra in real world situations without demanding all the symbolic dexterity required from calculus-bound students. The expected learning outcomes include: 1. Formulate real world situations in mathematical forms, including graphs, tables, diagrams or equations, and in words. 2. Execute symbolic manipulations and computations in order to solve a posed problem. 3. Recognize and be able to combine and evaluate fundamental mathematical expressions and functions such as polynomials and exponentials. 4. Interpret the mathematical result about real world situations derived mathematically. Besides regular homework, quizzes and exams, the course assessment also included essay-writing and other open-ended questions, and group poster projects. An end-of-course survey revealed that MATH 109 students had a more favorable attitude towards the meaningfulness and usefulness of algebra than those in calculus-bound algebra sessions. (Received September 16, 2008)

1046-C1-2027 **Jose H. Giraldo*** (jose.giraldo@tamucc.edu), Mathematics and Statistics Department, Texas A&M University-Corpus Christi, 6300 Ocean Dr, Corpus Christi, TX 78412. *Making First Year Mathematics More Relevant To Science Students: Connecting mathematics and science courses.* Preliminary report.

Texas A&M University - Corpus Christi under a STEP/NSF grant started an innovation in the curriculum for first year science students. The main goal of the STEP program is to help freshmen science students succeed in their program and in particular in the mathematical component. To achieve this goal the program has brought together a team of mathematics and science faculty teaching these courses. In this presentation we will discuss the pedagogical approach to teach these courses, difficulties recruiting faculty to teach those courses, professional development and results, an attitude and mathematical preparedness of science students toward mathematics. The data collected so far indicates a positive relation between mathematics success and success in science, which reinforces research findings indicating the success of science students who have better mathematical preparation. (Received September 16, 2008)

Cryptology for Undergraduates

1046-D1-41 **Blake Rice**, **Neil Sigmon** and **Bill Yankosky*** (byankosky@ncwc.edu), North Carolina Wesleyan College, 3400 North Wesleyan Boulevard, Rocky Mount, NC 27894. *The ElGamal Cryptosystem on the TI-83.* Preliminary report.

Like the RSA cryptosystem, implementation of the ElGamal cryptosystem over the group of units modulo p, where p is a prime, is relatively simple in that it only requires students to have an understanding of exponentiation, modular arithmetic and some elementary group theory properties. All of these topics are accessible to students, even those who are not necessarily majoring in mathematics. Using a TI-83 to aid in the implementation of cryptosystems allows students to be able work with larger integers than they could feasibly work with by hand. The purpose of this presentation is to show how some graphing calculator programs can be used to implement the basic ElGamal cryptosystem over the group of units modulo p using the TI-83. (Received June 28, 2008)

1046-D1-170 **Alan Koch*** (akoch@agnesscott.edu), 141 E. College Ave., Decatur, GA 30030.
Cryptology as First-Year Seminar: Challenges and Rewards.

As part of Agnes Scott College's First-Year Seminar program, in Fall 2007 I taught a seminar entitled "Cryptography and Cryptology: The Making and Breaking of Secret Codes". This talk will describe the seminar and discuss the difficulties of constructing such a class within the guidelines of our writing-intensive Seminar program. Fortunately, the course provided unexpected benefits, both to the student and the college, which will also be outlined here. (Received August 11, 2008)

1046-D1-230 **Mike May*** (maymk@slu.edu), Department of Math and Computer Science, Saint Louis University, 220 N Grand Blvd, St Louis, MO 63103. *Explorations of elliptic curves in undergraduate cryptography with minimal student background through the use of Maple worksheets.*

Elliptic curves have become a standard tool in modern public key cryptography, but they are often omitted from an undergraduate course because of computational and mathematical difficulty. At Saint Louis University, we have been teaching a course in cryptography that has only Calculus II as a prerequisite. We have made the material more accessible through the use of Maple Worksheets. This talk will focus on explorations of elliptic curves through the use of worksheets. It will show some of the explorations made accessible to the students and highlight the cryptographic uses and underlying algebraic concepts illustrated by the explorations. (Received August 21, 2008)

1046-D1-717 **Amber M Rogers*** (Rogersa2@nku.edu), Department of Mathmatics, Northern Kentucky University, Highland Heights, KY 41099. *An Introduction to Algebraic Cryptanalysis.*

Algebraic cryptanalysis is a relatively new form of cryptanalysis which involves representing a cipher as a system of multivariate polynomial equations and using a computer to solve the system. This talk will be an introduction to the basics of algebraic cryptanalysis. An example based on the Keeloq cipher will be used to demonstrate how the polynomial system can be built. (Received September 10, 2008)

1046-D1-1127 **Tamara B Veenstra*** (tamara_veenstra@redlands.edu), 1200 E. Colton Avenue, Mathematics Department, University of Redlands, Redlands, CA 92373. *The Vigenere Cipher: A historical cipher with a modern day application.* Preliminary report.

I have taught a wide variety of courses involving the mathematics of cryptography. These range from an introductory general audience course to an upper level course for mathematics majors. I will provide a brief summary of topics covered in each of these courses. Then I will discuss the historical Vigenere cipher that involves some interesting topics in probability (combinations and permutations) and statistics (frequency analysis of different types of cipher and plain text) to attack this cipher. I will also present how this corresponds to the modern day binary stream ciphers. If time remains I will discuss the connection between linear feedback shift registers, which can be used to generate stream ciphers and special types of polynomials over finite fields. (Received September 14, 2008)

1046-D1-1363 **Neil P Sigmon*** (npsigmon@radford.edu), Radford University, Department of Mathematics, Radford, VA 24142, and **Jonathan D Dixon** (jdixon16@radford.edu), Radford University, Department of Mathematics, Radford, VA 24142. *An Interactive Demonstration of the Navajo Code of World War II.* Preliminary report.

The Marine Navajo Code talkers played a vital role in providing secret communications for the United States and were instrumental in the American victory in the Pacific theater in World War II. In this presentation, a description of the events leading up to the development and implementation of the code will be given. The code, its use on the battlefield, and how the code baffled the Japanese will be briefly described. To demonstrate how the code can be used to encipher and decipher messages, an interactive computerized version of the Navajo Code involving Maplets will be given. (Received September 15, 2008)

1046-D1-1479 **Joshua Brandon Holden*** (holden@rose-hulman.edu), CM#125, 5500 Wabash Ave., Terre Haute, IN 47803. *Teaching the Group Theory of Permutation Ciphers.* Preliminary report.

One of the first topics often taught in an abstract algebra class is permutations, since they provide good examples of non-commutative finite groups which the students can manipulate and visualize. This visualization is often done through symmetry groups. For students who are less geometrically inclined, however, the use of permutation ciphers provides another good way of motivating permutations. They can easily be used to illustrate composition, non-commutativity, inverses, and the order of group elements, which are fundamental topics in group theory. We will give examples of how this can be done and suggest other courses besides abstract algebra in which this could also prove useful. (Received September 15, 2008)

1046-D1-1613 **Jeffrey A Ehme*** (jehme@spelman.edu), Dept of Mathematics, Box 214, 350 Spelman Lane SW, Spelman College, Atlanta, GA 30314. *Finding Irreducible Polynomials Using Miller Rabin Type Tests.*

Irreducible polynomials play a vital role in constructing the finite fields that are commonly used in cryptology. In this presentation we will review the pertinent mathematics needed to extend the Miller Rabin test to arbitrary finite fields and then apply this test to find polynomials that are "probably" irreducible. Along the way we will discuss fast methods for finding square and cube roots in finite fields. (Received September 16, 2008)

1046-D1-1645 **Thomas R. Hagedorn*** (hagedorn@tcnj.edu), Department of Mathematics and Statistics, The College of New Jersey, Ewing, NJ 08628-0718. *Quantum Computing for Undergraduates.*

In a recent undergraduate cryptography course aimed at junior and senior mathematics and computer science majors, I included the topic of quantum computing. I will discuss how it was presented, the positives and the negatives of its inclusion, and student responses. (Received September 16, 2008)

1046-D1-1859 **Annela R Kelly*** (akelly@rwu.edu), Roger Williams University 1 Old Ferry Road, Bristol, RI 02809. *Investigations with Private-key Ciphers.* Preliminary report.

My talk will discuss projects that can be assigned in the cryptology course for majors or non-majors. My students have worked on creating new private key ciphers by combining or creating two ciphers and describing the properties of the new code. The students have also worked on finding fixed points in some ciphers. For example, in the affine cipher, this project involves number theoretical calculations. (Received September 16, 2008)

1046-D1-2016 **Maryam Vulis*** (mlv2007@earthlink.net), 67-67 Burns St, Apt. 4k, Forest Hills, NY 1175. *The Venona Project.*

The Venona project, created in 1943, helped decipher Soviet Intelligence messages.

It exploited the vulnerability of one-time pads which were used and reused by the Soviets in diplomatic and intelligence traffic.

The Venona project examined cryptosystems with number encoding. The use of one-time pads would have made decryption impossible if not for mistakes and brute force analysis.

Work on the Venona project continued for 40 years, and some of the translations were eventually declassified. (Received September 16, 2008)

1046-D1-2060 **Eric West*** (ewest@benedictine.edu), 66002. *Arithmetic in the field F_{2^8} as used in the Advanced Encryption Standard.*

The Rijndael algorithm of the Advanced Encryption Standard (AES) is a symmetric-key algorithm that is in widespread use and has the official sanction of our government for all purposes. As such it seems especially pertinent to expose our students to it. However, teaching the AES to undergraduates with little advanced math background can seem a challenge, partly because of the fact that key operations of the algorithm take place in the finite field F_{2^8}. I will discuss the basic structure of the algorithm, how the field operations are used, and the hands-on approach I take to explain the topic in the cryptology class I have been teaching for a mixed audience of mathematics and computer science majors. (Received September 17, 2008)

Demos and Strategies with Technology that Enhance Teaching and Learning Mathematics

1046-E1-24 **Bill Marion*** (Bill.Marion@valpo.edu), Dept. of Mathematics and Computer Science, Valparaiso University, Valparaiso, IN 46383. *Conjecturing the Sum of an Infinite Series: CAS Lab Exercise in Calculus I.*

If done well, laboratory exercises using a CAS tool in a Calculus course can enhance the students' understanding of certain mathematical concepts, especially those for which there is little class time devoted to the topic. Such is the case for the definition of the sum of an infinite series. Most texts cover this material in one section (typical examples being the geometric series and telescoping series) and quickly go on to convergence tests and Taylor and Maclaurin Series. Even when the limit of a sequence of partial sums definition is illustrated via the geometric series, not many examples of applying the definition are provided before students are presented with the proof of the general sum. In this paper the author will illustrate (using Maple) a number of examples he developed to improve students' comprehension of this central idea. The examples are special cases of the geometric series which lend themselves to some nice conjectures about what the sum should be. Based on experimenting with Maple, he will explain how he developed the exercises, how they were used to help students form conjectures, how he assessed the students' understanding, what he learned and what he would do differently. (Received June 08, 2008)

1046-E1-26 **Ivo D. Dinov*** (dinov@stat.ucla.edu), SOCR Resource, UCLA Statistics, 8125 Math Sciences Bldg., Los Angeles, CA 90095. *Interactive, Data-Driven and Technology-Enhanced Approach for Probability and Statistics Education.*

Recent technological advancements, research-motivated projects and novel interactive graphical tools provide a valuable platform for developing new and effective approaches for enhancing the probability and statistics education. In this presentation, we will demonstrate hands-on a new technology-blended pedagogical approach for teaching and learning probability and statistics. This approach is based on curricular integration of free, open-source, Internet-accessible, collaborative and multilingual materials including data, statistical methods, dynamic demonstrations and computational tools. All of these learning materials and interactive aids are freely available online http://www.SOCR.ucla.edu/. The research data provided is derived from various scientific studies and is made freely available on the Internet. Electronic WIKI EBooks and tutorials form the basis for the statistical methodology and concept definitions. Interactive web-based hands-on activities are used for demonstrations and self-learning. Finally, HTML interfaces provide access to JAVA-based computational libraries and tools. Each of these four concepts will be illustrated in the context of some common probability and statistics examples. (Received June 09, 2008)

1046-E1-198 **Mary Ann Connors*** (mconnors@wsc.ma.edu), Department of Mathematics, Westfield State College, Westfield, MA 01086. *Integrating Engineering Technology into the Teaching of Mathematics.*

This presentation describes a professional development interdisciplinary graduate course designed to enable middle school mathematics teachers to deepen their knowledge of mathematics and engineering technology concepts and to develop hands-on classroom activities. The focus of this course includes hands- on activities integrating mathematics, technology, and engineering design. The activities can also be modified for high school and undergraduate college level courses. The presenter will describe and demonstrate some examples of the activities integrating appropriate technology, including building and testing bridges, parachutes, roller coasters and other relevant models. (Received August 18, 2008)

1046-E1-422 **Kimberly J Presser*** (kjpres@ship.edu), Shippensburg University, Department of Mathematics, Shippensburg, PA 17257. *Turning Point Technology: Using Personal Response Systems to Stimulate Class Participation.* Preliminary report.

In the last year our department has had a classroom set of clickers from Turning Technologies. This system uses a program called Turning Point (which is Power Point with extra features) to capture audience answers into a Power Point presentation. This program has been utilized in several courses including developmental mathematics, statistics, mathematical modeling, a probability seminar, and a graduate course in technology. In developmental mathematics, the system was used to coordinate student competitions to review. Students who had been reluctant to participate in class prior to the competitions became very enthusiastic participants under the competition model. The PRS system allowed everyone's response to count so that all of the students needed to participate. Prior to using the PRS system, we had some student competitions in class, but the logistics had been a problem. The students took the competition and fairness very seriously and white boards and raised hands were difficult to manage. The use of the PRS system made the competition more manageable and encouraged everyone to be prepared. In addition, the PRS system was used for exam review and proved useful for rooting out common misconceptions about the concepts discussed in class. (Received September 02, 2008)

1046-E1-600 **Anand L. Pardhanani*** (pardhan@earlham.edu), Department of Mathematics, Earlham College, Richmond, IN 47374. *A powerful, easy-to-use computer algebra alternative that students love, but (most) teachers have not yet discovered!*

Teaching with technology that combines powerful graphics with sophisticated mathematics is known to be very effective. Many quality products strive to meet this need, including Maple, Mathematica, Matlab and others. While these tools have been successful and effective for some students, many other students (and teachers!) find the learning effort prohibitive, or beyond their capacity. This has been particularly true in my lower-division undergraduate courses, where technology is precisely what I need to attract and help students.

In this presentation I will demonstrate a powerful, new, inexpensive alternative to sophisticated computer algebra systems. I will also demonstrate class activities and labs I have developed based on this technology for calculus and differential equations. The typical student profile in these classes has been broadly multidisciplinary, with wide disparities in their math skills and preparedness. Such classes not only require appropriate technology, but also appropriate ways to integrate it into an effective learning experience.

A strong argument in favor of this technology is that students love it, and use it enthusiastically in my labs. But the best measure of its success has been seeing them use it for other classes and personal interests! (Received September 08, 2008)

1046-E1-650 **Douglas B Meade*** (meade@math.sc.edu), Department of Mathematics, Columbia, SC 29208, and **Philip B Yasskin** (yasskin@math.tamu.edu), Department of Mathematics, 3368 TAMU, College Station, TX 77843-3368. *Effective Teaching and Learning with the Right Web-Based Resources.*

Finding eye-catching web-based resources is easy. The challenge is to find effective ways to use them – within the classroom and beyond. Resources that merely solve the problem for the students or show them the solution do not engender true learning. The students need to be thinking through the solution process for themselves.

This presentation highlights the Maplets for Calculus (M4C) – a collection of 94 Maple applets illustrating most of the topics in single variable calculus. (See http://m4c.math.tamu.edu/) Each maplet is designed to be usable in several different settings: in a laboratory for student exploration, in the classroom for demonstrations, or by students seeking additional practice with immediate feedback. The maplets use a combination of symbolic, graphic (2D or 3D, sometimes with animation), numeric and verbal devices to investigate problems. Problems are either algorithmically generated or explicitly entered by the student or instructor. The maplets require the user to work through the problem step-by-step requiring correct answers to earlier steps before later steps, or the final answer, can be checked. Hints are available and when errors are detected, instructive feedback is provided. All of this enables students to use M4C as "a tutor without the tutor." (Received September 09, 2008)

1046-E1-793 **Steven Hetzler*** (SMHetzler@Salisbury.edu), Dep't of Math & C.S., Salisbury University, 1101 Camden Ave., Salisbury, MD 21801, and **Robert Tardiff**. *Auditory Graphs in Excel for Calculus.*

To engage students in general as well as communicate more effectively with those who are not visual learners, we developed a software tool that represents a function both as a varying pitch and as a standard graph. Users familiar with spreadsheets will find this software tool easy to learn and use; it is implemented in Excel. It is an application of sonification which is the use of abstract sounds to represent data and, more precisely, an implementation of an auditory graph, a sound whose pitch at time t is determined by the value of a function at time t. The tool synchronizes an auditory graph with an animation that draws the function's graph as the sound plays – a sonimation. Materials have been developed where students can explore limits, qualitative properties of functions and derivatives, and integrals and Riemann sums in computer laboratory sessions. Instructors can also use sonimations in a computer equipped classroom for demonstrations. We will present a sample of sonimation activities and exercises used to measure the effectiveness of sonimations as a means for helping students learn calculus. This work has been partially supported by a grant from the NSF: DUE – 0442450. (Received September 11, 2008)

1046-E1-897 **Denise J LeGrand*** (djlegrand@ualr.edu), UALR Mathematics Dept, DKSN Hall rm 600, 2801 S University Ave, Little Rock, AR 72204. *All You Add is Webassign and Maple.* Preliminary report.

With new technology, methods of teaching and learning more effectively are now available. Teaching Calculus online has many challenges and one of them is how to handle homework. Webassign, an online homework program, is the answer I have found that works for both the student and the teacher. In this presentation I will show how I use Webassign in online Calculus courses and why I changed how I used it to improve the results. I will cover class policies and settings for the online homework. I will demonstrate how I answer students questions using a tablet PC , Camtasia, and TI SmartView, as well as other tools which can be found free on the internet. Short videos and podcasts which I make can easily explain and answer student questions. The videos can also show the students how to use the software and give step by step directions for both Webassign and Maple. Maple projects are required for the Calculus courses and I will also explain how the projects are assigned and graded for the online sections. The feedback is almost immediate since the projects can be returned, easily marked and graded soon after they have been received. All of the tools are readily available with little to no learning curve. (Received September 12, 2008)

1046-E1-911 **Paul 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 semester of this assessment will be shared. (Received September 12, 2008)

1046-E1-1169 **Marilyn Reba*** (mreba@clemson.edu), Martin Hall 0-202, Department of Mathematical Sciences, Clemson, SC 29631, Clemson, SC 29631. *PEN-TECHNOLOGY AND EVOLVING WEB-BASED INSTRUCTION TOOLS IN FRESHMAN CALCULUS.*

Too many students in first-semester Calculus are unprepared for the pace at which new concepts are introduced, are unable to implement prerequisite Algebra skills, and are unwilling to seek answers to their questions in class. Pen-technology via Tablet PCs and web-based software offers creative opportunities to communicate with struggling students. Our usage of this technology has evolved over four semesters. We have moved beyond the projection of anonymous student-inked submissions and "personalized" feedback on group activities to include student-generated audio-video podcasts and, in Fall 2008, to the weekly remediation of targeted calculus-algebra skills via instructor-created automated inked quizzes. We also have made progress (given a recent NSF grant) on a replay-ink and tagging feature. The tags, in addition to providing analysis of student errors and the creation of better teaching materials to remedy these errors, will also be used to provide detailed feedback to each individual student. (Received September 15, 2008)

1046-E1-1354 **Christopher M Smith*** (christopher.m.smith@us.army.mil), MADN-MATH, 646 Swift Rd, West Point, NY 10996, and **Frank Wattenberg**, **Josh W. Helms** and **Rodney Sturdivant**. *Developing a Video Tutorial Library to Service Upper Level MSE Courses.* Preliminary report.

This talk will discuss a use of technology to develop a library of video tutorials for a student's use in future math and science courses. In an undergraduate math course that is a prerequisite for upper level courses a student might possibly miss or forget a concept that is paramount to success in the upper level courses. By creating this library of tutorials educators can better serve the student and instructor of upper level math and science classes. (Received September 15, 2008)

1046-E1-1399 **Hugh W. McGuire*** (mcguire@cis.gvsu.edu), 1 Campus Drive, Allendale, MI 49401-9403. *ProofBuilder, a Tool for Showing Students How to Construct Basic Proofs.* Preliminary report.

`ProofBuilder` is a piece of software that helps students learn how to construct proofs. It is intended for basic Discrete Mathematics and bridge courses, covering topics such as basic number theory, sets, summations, combinatorics, and order of magnitude ($O()$ etc.). It uses proper Mathematical symbols, e.g. "$\forall$" and "$\in$"; and it provides a full range of proof methods: substitution of equivalents, application of comparisons ("$<$", "$\geq$", etc.), direct proof, backward reasoning, proof by contraposition, splitting into cases, resolution, induction, proof by contradiction, etc. It is flexible, accommodating different styles of logic — different symbols, deductions, etc.;

and it runs on different computer platforms: Windows, Mac, LINUX, etc. `ProofBuilder` avoids doing all reasoning automatically for student users, so they will still learn to do logical reasoning; but it does help students by helping to organize all the myriad elements of a proof and preventing clerical errors, e.g. when one wants to change some parts of a formula and copy the rest unchanged. The following Website provides documentation:

`http://www.cis.gvsu.edu/~mcguire/ProofBuilder/`

(Received September 16, 2008)

1046-E1-1439 **Shemsi I Alhaddad*** (`alhaddad@gwm.sc.edu`), P.O. Box 889, Lancaster, SC 29720, and **Greg Thomas**. *Using Tablet PCs and the Ubiquitous Presenter to engage students and enhance the learning experience in service courses.* Preliminary report.

The Ubiquitous Presenter is a presentation system that allows the instructor to write on prepared slides during class with digital ink. Students can interact anonymously with the instructor during class by adding ink or text to slides and submitting their work via the Internet. Student submissions may also be done outside of class. After class, all slides are available to the students via the web. We are currently using the system to determine if peer review increases the accuracy of student self-evaluation. We describe how we use the Ubiquitous Presenter in class and its effect on the classroom atmosphere. We also present preliminary results of the student self-evaluation study. (Received September 15, 2008)

1046-E1-1480 **Joshua Brandon Holden*** (`holden@rose-hulman.edu`), CM#125, 5500 Wabash Ave., Terre Haute, IN 47803. *Math in Your Hands: The Use of Tablet PCs and Computer Algebra Systems in a Calculus Classroom.*

In the Fall Quarter of 2008 we explored the use of Tablet PCs in calculus classes in order to foster student engagement by incorporating active learning and collaborative activities. The use of tablets can make many improvements in a classroom, but mathematics classes pose special challenges which have not yet been systematically explored at Rose-Hulman. The most difficult of these from a technical perspective is the integration of computer algebra systems such as Maple with other Tablet PC software. This project explores ways to achieve this integration as well as other pedagogical improvements which the use of Tablet PCs could bring to mathematics classrooms. We will report on the reactions of students as well as the impressions of the professor. (Received September 15, 2008)

1046-E1-1673 **Dexter C. Whittinghill*** (`whittinghill@rowan.edu`), Department of Mathematics, Rowan University, Glassboro, NJ 08028. *My First Semester Using 'Clickers' for Rapid Feedback: The Good, the Bad, and the Ugly.*

'Clickers', or audience response devices like the TurningPoint Response Card or the iClicker, are devices for obtaining rapid-feedback from your students in the course of a lecture, in order to gauge the proportion of students who have learned a concept. After posing a question to the students, depending on the proportion of correct answers the instructor has three choices. If over 80% (say) get the correct answer, the instructor can acknowledge that. If there is only a plurality of correct answers, he can have the students discuss the problem with each other (and possibly re-poll). If a high percentage get it wrong, he can further explain the topic. When used by a knowledgeable and practiced instructor clickers are an impressive tool (the Good). When used by a rookie there can be some unfortunate effects on the lecture (the Bad) or even some embarrassing and disastrous moments (the Ugly). This talk will include what motivated this instructor to try clickers, the context in which the clickers were used, and examples of the kinds of questions used in the class. The forty people who sit in the front will get to try the clickers! (Received September 16, 2008)

1046-E1-1695 **Itai Seggev*** (`iseggev@knox.edu`), Knox College Box 80, 2 E. South St., Galesburg, IL 61401. *Using 3-Dimensional Bifurcation Diagrams to Enhance Student Learning.*

One of the basic phenomena of differential equations is bifurcation: that small changes in a parameter can cause large, qualitative changes in the global behavior of solutions. Traditionally, the structure of bifurcations is depicted using one of two 2-dimensional representations. If the dependent variable is y, its rate of change is y', and c is the parameter, then one representation is to plot several curves of y' versus y for several values of c on the same set of axes. The other is to plot y_{eq} (the equilibrium value of y, where y' is zero) versus c and somehow indicate which branches contain stable equilibria and which branches contain unstable equilibria. Students find both of these representations difficult to interpret. Instead, I suggest using a three dimensional plot showing the relationship between all three variables at once. This contains all the information of both 2D plots and more. With modern software, such plots are relatively easy to create, and students find them much easier to interpret. The talk will include Mathematica demonstrations. (Received September 16, 2008)

1046-E1-1715 **Sandra Schroeder***, Department of Mathematics, Ohio Northern University, 525 S. Main Street, Ada, OH 45810, and **Mihai Caragiu**. *On the combined use of algebra and technology in the study of a family of sequences.* Preliminary report.

It is known that the iterations, starting from any positive multiple of 3, of the function which associates to every positive integer the sum of the cubes of its base ten digits, eventually leads to the number 153. This leads us to a class of problems in which the use of technology to discover the limit cycles of similarly defined sequences is particularly useful as a classroom experience, since it provides an example of creative interaction between computer applications and algebra calculations performed by the students. (Received September 16, 2008)

Developmental Mathematics Education: Helping Under-Prepared Students transition to College-Level Mathematics

1046-F1-18 **John F Loase*** (john.loase@concordia-ny.edu), Concordia College, 171 White Plains Rd., Bronxville, NY 10708. *Statistics: The Key to College Success for Educationally Under-Prepared Students.* Preliminary report.

IN 2005, the United Stated Department of Education revealed mathematics to be the most serious obstacle to college graduation in the U.S. The report went on to characterize mathematics as an insurmountable barrier for the economically disadvantaged student. In Dec. of 2007, Loase presented a sequence of strategies to remedy this problem("Statistics: The Key to Success in College and Life", Focus). This talk will discuss the way Concordia College-NY breaks down this "insurmountable barrier" to college success with a near 100% success rate in Statistics of those, who attend regularly . Loase's past innovations in remedial mathematics ("An Alternative to Computer Assisted Instruction", Communicator, 1987), were promising in that the success rate in individualized remedial courses was statistically significantly increased . Unfortunately, these courses were very expensive and available to a select few. The statistically significant innovation did not significantly increase the graduation rate of the economically disadvantaged students. We need to rethink our role, as college professors, in the epedemic of remedial mathematics failure, scrutinize how our requirements may contribute to this societal problem, and innovate solutions. (Received May 16, 2008)

1046-F1-358 **Euguenia V Peterson** (epeterson@ccc.edu), 7500 S. Pulaski Rd., Chicago, IL 60652, and **M. Vali Siadat*** (vsiadat@ccc.edu), 7500 S. Pulaski Rd., Chicago, IL. *Combination of Formative and Summative Assessment Instruments in Elementary Algebra Classes at the College.* Preliminary report.

We will present the findings of our comprehensive research study on the effects of implementation of formative and summative assessments on achievement and retention of students in elementary algebra classes at Richard J. Daley College. The methodology used was the Keystone method which is based on the centrality of student learning and continuous adjusting of the teaching practices. This method incorporates frequent quizzing, feedback, and reteaching in order for students to attain mastery. Using experimental/control group design it was found that approximately after four months, students (N=222) who were in the Keystone group achieved significantly higher scores on the final examination than the students in the control group (1352). The higher improvements in student performance were achieved in conjunction with higher retention rates. The results obtained on internal summative assessments were also highly correlated to the external examination scores. (Received August 27, 2008)

1046-F1-686 **Carla V. Gerberry*** (cliguore@purdue.edu). *Females in mathematics: Why aren't they persisting? And what can we do to encourage them to stay?* Preliminary report.

While current research shows diminishing gender differences in mathematics achievement, females are still failing to persist in STEM fields. This study focused on the self-efficacy beliefs of females in mathematics as a potential reason. The research question for the study was: How are high school females' self-efficacy beliefs influenced by their participation in cooperative group work in mathematics class? Data collected were videotaped sessions of cooperative work, and surveys pertaining to self-efficacy beliefs of females. Preliminary results of the study indicate that those females who adopted roles requiring them to explain and speak to others in the group increased in self-efficacy. This increase may be attributed to the presentation of mathematics in such a way that students verbalize their ideas and are encouraged to think about mathematics in a more nontraditional way. Implications are that presenting mathematics in such a way can increase perceptions of ability and may, therefore, increase persistence in mathematics and other STEM fields. (Received September 10, 2008)

1046-F1-830 **Yun Lu*** (lu@kutztown.edu), Mathematics Department, Kutztown University of Pennsylvania, Kutztown, PA 19530. *Some thoughts from teaching math for business course.*

The math for business course in Kutztown University of PA is an entry level course with prerequisites of two years of algebra. Most of students take this course because they are required to do it, and not all of them are well prepared. In last couple of years, I tried different methods when teaching this course and asked for the students' feedback in order to figure out which method works better for them. In this talk, I will share some of my experience along with students' comments. (Received September 11, 2008)

1046-F1-921 **Cyrill Oseledets** (coseledets@ccc.edu), 7500 S. Pulaski Road, Chicago, IL 60652, **Vali Siadat** (vsiadat@ccc.edu), 7500 S. Pulaski Road, Chicago, IL 60652, and **Ming-Jer Wang*** (mwang@ccc.edu), 7500 S. Pulaski Road, Chicago, IL 60652. *Integration of the Keystone Methodology with Computer Technology.*

The Keystone method is a synergistic system of assessing students' learning and adjusting of teaching practices. It provides a medium for dialogue between the teacher and the students. This medium is represented by carefully designed quizzes which are frequent, cumulative, time restricted, and homework based. The daily quizzes are performance based and address students' learning difficulties. They are followed by the teacher providing immediate and constructive feedback on all the problems. The difficult topics are re-taught until an appropriate level of mastery is attained. Statistical analysis of the quizzes, such as item analysis on each question, average time spent on each question, as well as the mean and standard deviation of the entire quiz, provide valuable information about the class performance. This in turn helps the teacher to plan the next lesson and construct the next quiz. We are now incorporating the Keystone methodology with state of the art computer technology to perform in-class computer quizzing and assessment, providing instant diagnostics and feed back to all students. Technological support will reduce the time spent on construction of quizzes and tests and will also provide assistance to students with their homework and other related assignments. (Received September 12, 2008)

1046-F1-1167 **Dora Cardenas Ahmadi*** (d.ahmadi@moreheadstate.edu), Department of Mathematics and Computer Scienc, Morehead State University, Lappin # 105, Morehead, KY 40351. *Building Bridges to College Mathematics.* Preliminary report.

The College Algebra Program sponsored by Morehead State University enhances the teaching of algebra at eight high schools while improving college readiness in mathematics. Nine teachers and 140 students from East Carter, Elliott, Fleming, Lewis, Menifee, Morgan, Rowan, and West Carter high schools are involved in the program. Teachers and students participate in an instructional and support program that incorporates content instruction, technology, instructional strategies, and instructional partnerships. Taking a team teaching approach, seven MSU instructors teach three times a week at the high schools and serve as consultants throughout the academic year. The program was kicked off with a summer workshop in which MSU instructors and teachers planned the academic year, engaged in pedagogical discussions and built the rapport and confidence to make the program work. By successfully completing this course, participating students will be ready for a college mathematics course. (Received September 15, 2008)

1046-F1-1178 **Clyde L. Greeno*** (greeno@mathematicsinstitute.org), MALEI Mathematics Institute, P.O. Box 54845, Tulsa, OK 74155-0854. *RASM Reconstruction of the Developmental Mathematics Program.*

Clinical research through casework with students from developmental mathematics programs (DMP) confirms urgent needs for reforming the DMP in accord with the NCTM initiative for learning mathematics through "Reasoning And Sense Making" (RASM).

The typical DMP has only a meager rate (perhaps less than 20%) of preparing its students for genuine academic success in college-level mathematics courses. The failure is due partly to colleges being unwilling to "think outside the box" that they inherited from the high schools – the succession of three, time-locked, progress-graded, courses (arithmetic, basic algebra, intermediate algebra). From "outside the box", it is obvious that DMP students actually need a more viable kind of "personal mathematical fitness" program – in which learning mathematics-as-common-sense serves also as a therapeutic remedy for mathematics-learning distress (MLD).

Whatever its format, a RASM-reformed DMP must pivot around a developmentally continuous mathematical syllabus – one that is fully common-sensible to the students, themselves. Clinical research discloses that, where, and why the traditional DMP badly fails to be so – and how to repair it. Herein are surveyed some of the major mathematical changes needed of a RASM-reformed DMP. (Received September 15, 2008)

1046-F1-1199 **Robert E. Burks Jr.*** (robert.burks@usma.edu), 211B Barry Road, West Point, NY 10996. *"Rock Math" - Helping Under-prepared Students make the Transition to College Mathematics.*

The United States Military Academy's math curriculum is continually evolving to better meet the future needs of its students. All students entering the 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. However, every year approximately 5 percent of the freshmen enter under-prepared for success in the school's math sequence. These students are enrolled in a year long introductory 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 outcomes. (Received September 15, 2008)

1046-F1-1302 **Joy Moore*** (moorej12@xavier.edu), 112 Hinkle Hall, Mail Location 4441, Xavier University, Cincinnati, OH 45207-4441. *Successfully Transitioning Under-Prepared First-Year Pre-Calculus Students.*

The Emerging Ethnic Engineers Program (E3) is a comprehensive 5-year program dedicated to the recruitment, retention, academic and professional success of underrepresented ethnic minority students in the College of Engineering at the University of Cincinnati. One component of the program is the Cooperative Learning Pre-Calculus Program which includes an 8-week Summer Bridge Program and a First-Year supplement course experience. Grounded in the theoretical framework of social constructivism, this paper will detail aspects of the Summer Bridge Program and the First-Year experience that have been deemed effective by both the students and the resultant retention and academic success rates. E3 students' academic performance will be compared to other cooperative learning students as well as the general population of pre-calculus students. Collaborative efforts between program directors, mathematics faculty, and student support services will also be discussed. (Received September 15, 2008)

Environmental Mathematics

1046-G1-432 **Martin E. Walter*** (walter@euclid.colorado.edu), Campus Box 395, Unversity of Colorado, Boulder, CO 80309. *Weatherquakes, Earthquakes, Mathematics and Climate Change.*

Diverse phenomena such as the distribution of earthquakes, price variations of cotton futures, frequencies of city sizes and so on all follow simple power laws. Possibly some of the complexities of global warming/climate change yield to a similar mathematical analysis. In what appears to be deeper than mere analogy we define weather events to be weatherquakes, just as seismic events are referred to as earthquakes. We postulate the "Weatherquake Hypothesis" from which we conclude that the proportion of extreme weather events among all weather events can be expected to increase as concentrations of greenhouse gases, such as carbon dioxide, increase in the atmosphere. (Received September 02, 2008)

1046-G1-958 **Harel Barzilai*** (hxbarzilai@salisbury.edu), Dept of Mathematics, Salisbury University, 1101 Camden Ave, Salisbury, MD 21801. *Quantitative and Citizen Literacy through Key Environmental Issues of our time.* Preliminary report.

We describe the curricular development and first-time teaching experience for a 100-level Liberal Arts mathematics course centering on quantitative literacy and environmental topics. The course was taught via activities, group explorations and short readings (including newspaper articles) rather than a textbook, and touched on some of the major environmental challenges of our day, such as climate destabilization and climate feedbacks, Peak Oil, and exponential growth on a finite planet. Curricular materials will be shared which allow authentic quantitative explorations of these issues by students in a General Education course.

Related questions for discussion which arise include: how can relevant real-world examples be used to both motivate the study of, and also to deepen student understanding of, mathematical ideas? How can relevant mathematical ideas be included in a General Education course at a level which is accessible, while still providing students with powerful lenses and tools through which the complex issues in the world around them can be understood throughout their lives as citizens? (Received September 13, 2008)

1046-G1-1423 **Rachel M Dunwell*** (dunwellr@rhodes.edu), Rhodes College, 2000 North Parkway, Memphis, TN 38112, and **Christopher W Seaton**. *Teaching Applied Calculus through Environmental Modeling.*

As climate change becomes more of an important part of the lives of Americans, introducing students to the basic mathematical concepts used to predict climate change is appropriate at an early level and for a broad audience of college students whose focus is not mathematics or even a natural science. Although it is of course not practical to try to teach the sophisticated mathematical techniques involved in such models, students can become familiar with the process involved in producing, evaluating, and adjusting a model to study behavior and make predictions. In this talk, we discuss how we are introducing modeling techniques with an emphasis on climate modeling in a terminal first-semester Applied Calculus course at Rhodes College. Through a heavy emphasis on Mathematica, the students of this course learn introductory differentiation and integration by studying the modeling process itself, beginning with data collected by environmental scientists. We discuss the mechanics of this class as well as our assessment of its impact. (Received September 15, 2008)

1046-G1-1537 **Jennifer A Gorman*** (gorman005@gannon.edu), Mathematics Department, Gannon University, 109 University Square, Erie, PA 16541. *Starting in your own Backyard: Looking at Local Enviromental Risks in a Mathematical Modeling Class.*

We look at ways to use the local environment to enrich a mathematical modeling class. Specifically we look at ways of modeling various aspects of the Great Lakes, paying special attention to Lake Erie, using differential equations. We look at ways to use the models created in class to make predictions for the future of the Great Lakes. We also briefly discuss the impact that modeling a local ecosystem had on the engagement of the students during the class. The use of local resources used and the positive interaction that resulted from these interactions will also be discussed. (Received September 15, 2008)

1046-G1-1881 **Frederick A. Adkins*** (fadkins@iup.edu), 212 Stright Hall, Mathematics Department, Indiana, PA 15705. *A Curriculum Module for Modeling Bioaccumulation, Biomagnification, and Elimination of Toxins.* Preliminary report.

Bioaccumulation is the increase of a substance in organisms, as they take in contaminated air, water, or food more rapidly than it can be eliminated. As pollutants move from one link in the food chain to another they concentrate through the process of biomagnifications. Through a module designed for use in an introductory calculus course, students explore these concepts using data derived from research on mercury levels in the environment and aquatic food chain. Students begin by tracking mercury and other toxins across the food chain from algae and bacteria to humans. Students use their typical weekly consumption of fish to calculate their average daily dosage of mercury or PCBs per kilogram of body weight. Based on models of absorption from food, a separable differential equation modeling toxin elimination and the fraction of toxins circulating in blood, a time dependent equation for blood concentration is derived. Students then find their steady-state level of blood toxins and compare this to the U.S. Environmental Protection Agency's "safe benchmark blood levels." (Received September 16, 2008)

1046-G1-2058 **Ben Fusaro*** (fusaro@math.fsu.edu), Math. Dept, Florida State University, Tallahassee, FL 32306 4510. *Modelphobia - How does it arise; what can we do about it?*

Resistance to the use of modeling is not uncommon among field scientists (”naturalists”). However, after the failure of a model such as the Club of Rome ”Limits to Growth”, the resistance increases to the point of hostility. More recently, the poor predictive aspects of some marine fisheries models have led to a recent ”pox on models" reaction. Since models – from the most sophisticated structures (such as scientific theories) on down to matrices, differential equations, and even arithmetic, form the backbone of the scientific method, such responses are puzzling. We will discuss a recent polemic and suggest that (perhaps) a repressed aversion to mathematics is behind such reactions. (Received September 17, 2008)

Guided Discovery in Mathematics Education

1046-H1-780 **Jennifer Earles Szydlik*** (szydlik@uwosh.edu), Math Department, UWO, 800 Algoma Blvd, Oshkosh, WI 54901, and **Carol E. Seaman**. *Guided Inquiry and Mathematical Sophistication.* Preliminary report.

In our mathematics courses for prospective elementary teachers, we exclusively use guided-inquiry to motivate and generate the content and to foster mathematical sophistication (specific behaviors, values, and habits of mind of the mathematical community). During the past two years we have designed a paper-and-pencil, multiple-choice instrument to measure mathematical sophistication, and this fall we assessed both the validity and reliability of the instrument with a large sample of undergraduates. We hope that our instrument will prove a valuable tool for assessing outcomes of problem-based pedagogies by capturing changes in facets of student learning not typically assessed by exams focused on course content. In this presentation, we will share our mathematical sophistication categories, our instrument, and the preliminary results of our study. (Received September 11, 2008)

1046-H1-954 **Brooke Evans*** (bevans21@mscd.edu), Dept. of Mathematical and Computer Sciences, Metropolitan State College of Denver, Campus Box 38, P.O. Box 173362, Denver, CO 80217-3362, and **Patricia McKenna**. *An Electronic Classroom Model for Mathematics Content Courses: Influences on K-12 Classroom Teaching.*

Metro's Math for Rural Schools Program was developed to offer rural teachers in Colorado an opportunity to take college-level mathematics content courses online. What makes this model unique is that the delivery of the courses model teaching practices which support development of mathematical proficiency and foster a mathematical community among teacher-learners. This session will summarize the course and speak to the unexpected influences on K-12 classroom teaching. The project utilizes small group teacher interactions which serve as an example of research-proven pedagogical approaches and as a way to foster collaboration and communication within the mathematics education community. The course begins with a face-to-face meeting where all of the teacher groups come together to begin problem-solving to establish classroom norms and become familiar with the technology. Then small groups of teachers meet in-person and are connected online (via voice, electronic whiteboard, instant messaging, and webcam) to the other groups and the instructors who facilities the learning experiences. We have found this method of delivery to be effective and believe it to be a good model for effective, high-quality electronic classroom learning experiences. (Received September 13, 2008)

1046-H1-1112 **Shlomo Libeskind*** (shlomo@uoregon.edu), Mathematics Department, University of Oregon, Eugene, OR 97403. *Teaching Number Theory: A Deductive Inquiry Approach.*

Number Theory is normally a required course for prospective high school mathematics teachers, and frequently the students' first introduction to proof. This article describes an approach to teaching Number Theory in a way that models a desirable way to teach mathematics in high school. The article emphasizes the importance of a full understanding of "theory" and proposes to teach "theory", not in the traditional "Definition – Theorem – Proof" form, but rather introduce theorems as problems, and proofs as solution of problems. In the process of the solution, a Polya type heuristics discovery approach is used. In that approach, the reasonableness of each step in a proof or solution is discussed and students' involvement is emphasized. The talk introduces several core theorems in Number Theory in the above described approach. Report on teaching other courses using a similar approach; in particular Junior level Geometry will be presented. (Received September 14, 2008)

1046-H1-1331 **Marie P. Sheckels*** (msheckel@umw.edu), Department of Mathematics, University of Mary Washington, 1301 College Avenue, Fredericksburg, VA 22401. *Comparisons of Guided Discovery and Problem Based Learning.*

Designing lessons that use investigative approaches to help students learn mathematics has long been advocated in the field of mathematics education. Guided discovery lessons and problem-based learning are both types of ways that teachers may structure their lessons to promote student learning. Is one approach better than the other in general or in particular cases? Does structuring lessons using different approaches result in different learning outcomes? The presenter has used guided discovery lessons for many years and has more recently started incorporating problem based learning in her classes. In this session, she will discuss an action research project she has conducted comparing the use of guided discovery lessons and problem based lessons. This presentation will compare the features of each approach and discuss the advantages and disadvantages of each based on students' attitudes and achievement. (Received September 15, 2008)

1046-H1-1350 **Reva Kasman*** (rkasman@salemstate.edu), Department of Mathematics, 352 Lafayette Street, Salem, MA 01970. *Guided Discovery in a Discrete Mathematics Course for Middle School Teachers.* Preliminary report.

Salem State College offers a graduate Master of Arts in Teaching program in Middle School Mathematics (MSM). In the spring semester of 2008 I taught the MSM Discrete Mathematics course exclusively through guided discovery. The course was structured around a set of notes designed for undergraduate math majors, originally written by Kenneth Bogart and later adapted by Mary Flahive. In this talk I will describe the practical logistics of teaching the course and adapting the materials for the middle school teachers. I will also discuss student response to the non-traditional format of the text and the unconventional instructor/student roles in the classroom, as well as benefits and challenges to using discovery-based learning with this audience. (Received September 15, 2008)

1046-H1-1458 **Jerome Epstein*** (jerepst@att.net), 34-13 87th Street, Jackson Heights, NY 11372-3352. *The Calculus Concept Inventory – New Data. Correlation with Teaching Methodology.*

I reported last year in San Diego on the development and validation of the Calculus Concept Inventory (CCI), a test modeled on the Force Concept Inventory (FCI) in Physics. It is designed as a pre-test/post-test instrument, testing only conceptual understanding of the most basic concepts of differential calculus. The FCI over decades has shown a very strong correlation of the normalized gain with teaching methodology, with "Interactive-Engagement" (IE) sections scoring dramatically higher than Traditional Lecture (TL) sections. A central goal of this project has been to find out if the same correlation with teaching methods is found also in calculus. Preliminary data at the last meeting was that the correlation was there, but the amount of data from I-E section was too small to be at all conclusive. We now have a lot more data, and the results will be shown in this presentation. (Received September 15, 2008)

1046-H1-1761 **Todd CadwalladerOlsker*** (tcadwall@fullerton.edu), 800 N. State College Blvd, Fullerton, CA 92834-6850, and **Nicole Engelke** (nengelke@fullerton.edu), 800 N. State College Blvd., Fullerton, CA 92834. *Student Proof Scheme Development in an Introductory Proof Course.* Preliminary report.

In this session, we will present the results of a guided discovery teaching experiment. Two sections of an introductory proof course were taught using the text Chapter Zero, by Carol Schumacher, with an emphasis on student presentation of proofs. The students were expected to spend a significant amount of time working on the proofs of theorems outside of class and with little direct instruction from the professors. In each class session, the majority of the time was spent on student presentation of proofs and discussion of those proofs. Our research focused on the development of proof schemes (as defined by Harel and Sowder) through these presentations. A questionnaire was administered to all students at the beginning and end of the semester. This questionnaire was designed to determine the proof schemes utilized by students when reading and interpreting proofs. The results were analyzed for statistically significant changes. We found that the use of deductive proof schemes increased, the use of empirical proof schemes decreased, but no change was found in the use of the external conviction proof schemes. We believe that the use of the guided discovery method improved the students understanding of the nature of proof. (Received September 16, 2008)

1046-H1-1780 **Tevian Dray*** (tevian@math.oregonstate.edu), Department of Mathematics, Oregon State University, Corvallis, OR 97331. *Teaching Calculus Coherently.* Preliminary report.

As reported last year, the Department of Mathematics at Oregon State University has recently begun an attempt to teach "coherent calculus" by adopting a "reform" text, using *ConcepTests* during lecture, replacing recitations by "labs", and holding weekly instructor meetings with time for discussion. In this talk, we will provide an update on our progress, including new data obtained through the use of the Calculus Concept Inventory (CCI) to measure student gains in conceptual understanding. (Received September 16, 2008)

1046-H1-1943 **Ian Whitacre*** (ianwhitacre@yahoo.com), Department of Mathematics and Statistics, San Diego State University, 5500 Campanile Drive, GMCS 415, San Diego, CA 92182, and **Susan D Nickerson** (snickers@sciences.sdsu.edu), Department of Mathematics and Statistics, San Diego State University, 5500 Campanile Drive, GMCS 415, San Diego, CA 92182. *Assessing the Effectiveness of Inquiry-Oriented Teaching in the Context of TA Professional Development.* Preliminary report.

This presentation addresses assessment of the effectiveness of discovery-based programs. The context for this research was a professional development program for university mathematics TAs teaching a math content course for preservice elementary teachers. The course curriculum emphasized student inquiry around topics in elementary mathematics. The course coordinator and TAs engaged in a form of lesson study. Two research lessons were conducted per semester during the 2007-2008 school year. The lesson study group assessed students' learning by means of both in-class assessment during the lessons and written post-test measures. A common final exam was administered in all sections. The final included problems specifically designed to address the goals of the research lessons. The Constructivist Learning Environment Survey was administered to the students and instructors of all sections of the course during the sixth and fourteenth weeks of each semester. We will present highlights of our analyses and discuss issues around assessment of the effectiveness of inquiry-oriented teaching in the context of TA professional development. (Received September 16, 2008)

1046-H1-1949 **Joan Ferrini-Mundy*** (jferrini@nsf.gov), National Science Foundation, 4201 Wilson Boulevard, Division of Research on Learning, Room 885.11, Arlington, VA 22230, and **Karen Marrongelle**, National Science Foundation, 4201 WIlson Boulevard, Room 885, Arlington, VA 22230. *Using "real world problems" to guide mathematics learning: Challenges in instructional practice and research.*

A discussion of the issues in conducting research about the impact of using real-world problems and contextualized situations as sites for students' learning of mathematical ideas. We will summarize the National Mathematics Advisory Panel's Instructional Practices Task Group report on the use of real world problems in K-8 mathematics instruction, including discussion of how "real world problems" have been defined and used in research and instructional practice. A summary of studies examining the effectiveness of this approach will be provided. We discuss needed research and implications of the findings for informing instructional practice at the K-8 level. We will also comment on related issues for the learning and teaching of undergraduate mathematics and for the preparation and professional development of K-8 teachers of mathematics. (Received September 16, 2008)

1046-H1-1957 **Susan D. Nickerson*** (snickers@sciences.sdsu.edu), CRMSE, 6475 Alvarado Rd, Suite 206, San Diego, CA 92120, and **Cassondra Brown**. *Embedded Assessments of Discovery-Based Learning.*

For the past two years, we have investigated changes in the mathematical knowledge of practicing teachers engaged in discovery-based programs, using what we call embedded assessments. The assessments are given in the course of the discovery-based learning as part of launching an exploration. The idea is to capture some information about student understanding on a task and then use these results to guide the teaching of the class. When we use the embedded assessments, we compare the student understanding at the beginning of a unit to the performance of the student at the end of the unit. We argue that there are a number of benefits to securing student performance in the course of activity one task at a time. There are limitations, as well, given that the administration of what serves as a pre-assessment is different than the administration of the post-assessment.

We will share some specific data from our assessment of discovery-based mathematics classes. More importantly, we will share what we have learned about assessing discovery-based learning–in particular what types of tasks have lent themselves to this approach and what types of tasks have been problematic in revealing what has been learned. (Received September 16, 2008)

Innovative and Effective Ways to Teach Linear Algebra

1046-I1-233 **Paul Raymond Bouthellier*** (pbouthe@pitt.edu), 504 East Main Street, Titusville, PA 16354. *Using Linear Algebra for Image Processing.* Preliminary report.

Given a bitmap image-which is nothing more than a matrix of pixels-each defined by a 24 or 32 bit hexadecimal number-we can use matrices to illustrate rotations, translations, skewing , and scaling in both R2 and R3. Projecting images onto surfaces such as spheres and cubes are also considered. As time permits, concepts such as backface-culling and reflections of light sources off surfaces-both which involve dot products-will also be illustrated. The package Flash CS3 will be used for the illustrations. (Received August 21, 2008)

1046-I1-450 **Patrick J Van Fleet*** (pjvanfleet@stthomas.edu), 2115 Summit Avenue #OSS201, Department of Mathematics, University of St. Thomas, St. Paul, MN 55105. *Using the Discrete Wavelet Transform to Illustrate Concepts from Linear Algebra.*

Wavelet theory is a relatively new development in mathematics and its origins are in functional and harmonic analysis, approximation theory, and linear algebra. Applications of wavelets are numerous and many utilize the discrete wavelet transformation (DWT).

The simplest DWT is the Discrete Haar Wavelet Transformation (DHWT). The very structure of this matrix makes it ideal for illustrating many ideas from linear algebra. Its block form is useful for demonstrating the power of block matrix multiplication. Writing a routine to implement the DHWT gives students a different look at matrix multiplication as well as the need for properties such as $(AB)^T = B^T A^T$. An intuitive approach leads to the inverse of the DHWT and shows that Gauss elimination is not always needed to compute inverses. In many applications, it is necessary to modify the DHWT so that it is an orthogonal matrix and when this orthogonal version of the DHWT is applied to digital images, it is a similarity transformation.

In this talk, we will introduce the DHWT, illustrate many of the points described above, and discuss how the DWT can be used in image compression. In this way, we provide linear algebra students with an example of a linear transformation that is used in the "real world". (Received September 03, 2008)

1046-I1-497 **Karsten K. Schmidt*** (kschmidt@fh-sm.de). *The Moore-Penrose inverse of a vector: Coping with a sometimes tricky case differentiation.*

The Moore-Penrose inverse (MPI) of an n by 1 (column) vector b is a 1 by n (row) vector. Its computation is a rather simple task, even though a case differentiation has to be made: If b is a zero vector, the MPI of b is the transpose of b (i.e. the 1 by n zero vector), otherwise it is the transpose of b divided by the inner product of b with itself (i.e. b'/(b'b)). If b only has numeric elements, it is easy to find out which case is on hand. If b contains at least one non-numeric element, the computation of its MPI might be as simple as before, but it might also turn out to be impossible to decide which case we have. This is made clear by some examples, using the Computer Algebra System Derive. We will then proceed to the computation of the MPI of a matrix containing at least one non-numeric element. For the actual computation of the MPI of such a matrix, we use a Derive function based on Greville's method - an iterative algorithm that needs n steps for the computation of the MPI of an m by n matrix. As Greville's method requires the computation of the MPI of a vector in each step, the difficulty mentioned above might prevent the actual computation of the MPI of a matrix with non-numeric elements. (Received September 05, 2008)

1046-I1-751 **Dean J Caffentzis*** (deanandcarole@verizon.net), 5005 Lillilea Lane, New Port Richey, FL 34653. *Geometric Representations of a 4x4 determinant.* Preliminary report.

Using (abcd/efgh/ijkl/mnop) as rows 1..4 respectively, the following maps define the 4x4 determinant.

Map Ia. (tuvw/uvwt/vwtu/wtuv), where t= -ankh,u= ebol,v= -ifcp,w= mjgd
Map Ib. (t'zyx/xt'zy/yxt'z/zyxt'), where x= -dejo,y= chin,z= -bglm,t'= afkp
Map II. (wxzy/xwyz/yzxw/zywx), where w= -afol,x= -ebkp,y= -dgin,z= -chjm
Map III. (ybcz/ezyh/iyzl/znoy), where y= -ajgp,z= -dfkm
Map IVa. (tvwu/uwvt/vtuw/wutv), where t= ajoh,u= dkne,v= pgbi,w= mfcl
Map IVb. (xt'zy/zyxt'/yzt'x/t'xyz), where x= agln,y= dfio,z= pjec,t'= mkhb
Map V. (ayzd/zfgy/yjkz/mzyp) where y= -bohi,z= -clne
total n! terms of the determinant = 24. (Received September 12, 2008)

1046-I1-1430 **Don Spickler*** (despickler@salisbury.edu), Salisbury University, 1101 Camden Ave., Salisbury, MD 21801. *The Linear Package and its Integration into an Undergraduate Linear Algebra Course.*

Linear is a Java application designed and written as a collaborative project between the students and faculty at Salisbury University. It was designed to be both a learning and exploration tool for the student as well as a demonstration tool for in-class examples and discussions. Linear has many standard facilities for matrix manipulations and calculations and some specialized facilities for concept visualization. In this talk we will demonstrate some of its capabilities and discuss its integration into an undergraduate Linear Algebra course. Linear can be found on my website at http://faculty.salisbury.edu/~despickler/personal/Linear.html. (Received September 15, 2008)

1046-I1-1440 **Murphy Waggoner*** (murphy.waggoner@simpson.edu), 701 N C Street, Indianola, IA 50125. *Getting Your Hands Dirty in Linear Algebra.*

I freely admit it: my worst grade in college was in linear algebra. This was probably because I did not understand what the numbers meant. I think that if I had been able to "get my hands dirty" by working on the applications of linear algebra, I would have connected more to the subject. I now know that my students have the same frustration.

To help the students get their hands dirty, they complete application projects and we hold a poster session. We invite the entire science division, and the students in the class must also peer review each other's posters. In this way, the students do not work on the applications in isolation, yet we do not have to take up class time with presentations.

The students say that the application poster session is the best part of the class, because it answers the questions, "How will I ever use this?" and "What does it all mean?" I like the poster session because the students take ownership of the subject, and they talk about mathematics to a general audience. I will talk about the structure of the project, how the students choose their applications, what the students are required to do, and how the poster session is organized and administered. (Received September 15, 2008)

1046-I1-1637 **Richard D. Neidinger*** (rineidinger@davidson.edu), Davidson College, Box 7002, Davidson, NC 28035-7002. *Algorithms for Multivariable Polynomial Interpolation.*

Does there exist a unique polynomial of degree d in n variables that agrees with values at (correct number) nodes? First, consider nodes as coordinates on a finite grid, using (hopefully few) tick marks on each axis. A general existence and uniqueness theorem always holds where the space of polynomials is the Span of classic Newton polynomials, e.g. a node at grid point (x_2, y_1) would correspond to $(x-x_0)(x-x_1)(y-y_0)$. With special node structure, the Span will be polynomials of degree d and an efficient divided-difference algorithm will produce the coefficients. More generally, the question asks if a multivariable Vandermonde matrix M is invertible. Recent algorithms can be explained by Gaussian elimination on M^T using blocks of the same monomial order. Row reduce to block identity matrices along the diagonal. If successful, these row operations on I produce normalized Newton polynomials that are one at a specific node but zero on all nodes of lower or same order. Then, a simple back-substitution algorithm can find coefficients. If unsuccessful, a row of zeros corresponds to a polynomial that is zero at all nodes, making existence and uniqueness impossible. Operations can stop sooner by using block matrix operations in Gaussian elimination. (Received September 16, 2008)

1046-I1-2023 **Stephen Hilbert*** (hilbert@ithaca.edu), Dept of Mathematics, Ithaca College, Ithaca, NY 14850. *Using Projects and Oral Reports in the First Linear Algebra Course.* Preliminary report.

While many instructors acknowledge that projects and/or oral reports are a valuable pedagogical tool, they feel that the time required to use them will detract from the content of the course. I have been using oral reports for over 25 years and written reports more recently in a sophomore level linear algebra course with about 20-25 students per section. In fact the use of the reports leaves students with a better overview of the topics of linear algebra than what we would accomplish in a week of regular classes. I will discuss techniques and resources as well as my experiences with projects and oral reports. (Received September 16, 2008)

1046-I1-2078 **Jeffrey Stuart*** (jeffrey.stuart@plu.edu), Mathematics Department, Pacific Lutheran University, Tacoma, WA 98447. *Teach ill-conditioning to introductory linear algebra students in a single lecture!*

Many students complete their one college course in linear algebra with the mistaken view that all invertible linear systems of equations behave the same way: that there is a unique solution, that Gaussian elimination finds it, and that there is no more to be said. We offer an easy, student-centered classroom activity that demonstrates that the solution behavior of small, invertible linear systems can be complicated, showing high sensitivity to small perturbations. The demonstration consists of four parts: a simple physical demonstration using commonly available items, student-performed computations, computer-based computations, and a final algebraic analysis.

The aim of this lesson is to develop an appreciation for the idea that linear systems can be ill-defined and for the role of geometry in ill-conditioning. Supplemental homework exercises demonstrate that poor scaling can also contribute to ill-conditioning.

In the author's experience, students are consistently surprised in the differences of behavior that can occur even in two by two systems. (Received September 17, 2008)

Mathematics and the Arts

1046-J1-45 **Jeffrey P. Smith*** (jsmith@otterbein.edu), Mathematical Sciences Department, One Otterbein College, Westerville, OH 43081. *Cracking Open the Books: Encouraging Undergraduates to Interact with Mathematic(al) Texts.* Preliminary report.

Numerous studies indicate compliance with collegiate course reading at 20-30% for any given day and assignment. Unfortunately, those percentages drop even further when examining reading patterns of undergraduates in introductory mathematics classes. This session explores strategies that encourage college students to read mathematical texts purposively. From Marking in the Moment to Post-Reading Post-Its, discover how to create experiences that motivate beyond "stick and carrot" accountability. Although data and anecdotes from a "math for the liberal arts" course will be highlighted, the ideas presented can be applied to nearly any math class. Bring your favorite textbook, article, or writing and take up the challenge to create an on-the-spot, engaging reading assignment - and be prepared to read! (Received July 02, 2008)

1046-J1-190 **Andrew J Simoson*** (ajsimoso@king.edu), 1350 King College Road, King College, Bristol, TN 37620. *Albrecht Dürer's Trochoidal Woodcuts.*

Albrecht Dürer, the great Renaissance German artist, is credited with being the first to introduce the hypocycloid curve along with the more general family of trochoid curves, as presented in his 1525 geometry treatise, *The Art of Measurement with Compass and Straightedge.* He argued at length that "geometry is that without which no one can either be or become a master artist." Did he use the trochoid in his woodcuts? We examine two cuts: *The Adoration of the Lamb* and *The Circumcision* and ask whether the lamb rests on a hypocycloidal arch within a circular halo and whether the vines adorning a synagogue wall follow a cardioid. We check it out using a little calculus and superimposing software generated trochoids upon his work. (Received August 15, 2008)

1046-J1-194 **Mike Huber*** (huber@muhlenberg.edu), Dep't of Mathematics and Computer Science, Muhlenberg College, 2400 Chew Street, Allentown, PA 18104. *The Calculus of the Quinto Acuto and Gothic Architecture.*

Are you "looking" for a good example to apply integration to calculate areas and volumes? Ever wonder where to find a practical example involving trig substitution? Then look at, not out, the window. In particular, locate an example of a Gothic window on campus and ask your students to calculate the area enclosed by the window. The rectangular towers, pointed arches, and stained glass tracery of Gothic buildings offer excellent examples of areas for students to calculate via integration. This presentation will offer examples of calculating areas of arched windows and ornate tracery, as well as volumes of domes, that have been used in the integral calculus classroom. (Received August 17, 2008)

1046-J1-327 **Susan McBurney*** (SMcBurney@prodigy.net), 211 Rugeley Road, Western Springs, IL 60558. *Weaving Mathematics.*

Technology has oftentimes advanced the arts by providing improved, and sometimes revolutionary methods with which the artist can achieve new levels of expression. One notable example was the Jacquard loom of 1804. This presentation will include a detailed illustration of the mechanics of the Jacquard loom, a discussion of it's importance not only to the weaving industry, but also to computer design more than a century later, and an examination of notational methods used to specify weaving patterns. This leads naturally to mention of the binary number system and Boolean algebra. Finally, a variety of weaving examples will be shown and a simple virtual weaving program used to create some surprising designs based on mathematical inputs. (Received August 26, 2008)

1046-J1-328 **Anne M. Burns*** (aburns@liu.edu), Department of Mathematics, Long Island University, C.W. Post Campus, Brookville, NY 11548. *Fractal Gardens.* Preliminary report.

The recursive nature of plant growth and other branching structures makes it an excellent topic for a course in Math and Art. Using mathematics that can be understood by an undergraduate mathematics major, four models of plant growth will be described. Using geometry, trigonometry and probability, a small number of rules can be applied recursively to produce a variety of fractal trees and inflorescences, revealing the importance of parameters in modeling. The concentration will not be on scientific accuracy, but rather in the production of art and the use of the methods in education. The result will be an animated growth of a "fractal garden". (Received August 26, 2008)

1046-J1-407 **Gary R. Greenfield*** (ggreenfi@richmond.edu), Math. and Comp. Sci., University of Richmond, Richmond, VA 23173. *On Ricochet Compositions for N-gons.* Preliminary report.

Ricochet compositions (see I. de Kok et al., 2007 Bridges Conference Proceedings, 177–180) are generated by placing a particle on each side of an n-gon, assigning it a starting angle, and assigning it a color. Then, one at a time, each particle moves until it encounters an existing line segment at which point it is reflected — the ricochet — and is paused so that the next particle may take its turn. There is also a polygon-fill rule: if a particle ricochets off its own orbit, then the area it has just enclosed is filled using its assigned color. We consider schemes for generating resolution free ricochet compositions on convex n-gons for $n \geq 3$. Further, we examine the use of evolutionary computation techniques for automatically generating ricochet compositions with differing styles. (Received September 01, 2008)

1046-J1-431 **Christine von Renesse** (cvonrenesse@wsc.ma.edu), 577 Western Ave, Westfield, MA 01086, and **Volker Ecke*** (vecke@wsc.ma.edu), 577 Western Ave, Westfield, MA 01086. *Mathematics of Salsa Dancing.*

In many dances, when you learn a new move, you have really learned two: the original one (e.g. to the right) and its mirror (e.g. to the left). Many more such symmetries exist: forward and backward,leading and following, with the dancers facing each other, or away from each other, etc. Motivated by an Argentine tango teacher explicitly exploiting such symmetries in his teaching, we became curious to explore their power in our Salsa dancing, as well.

With the talk, we intend to illustrate an approach to teaching mathematics that is well suited for liberal arts majors.

You will move with us through our analysis of possible starting and ending positions for a dance phrase, the rich mathematical symmetries and a range of possible dance moves that can take you from one to the other.

In the process, we discover some mathematical facts that many good leaders embody and exploit all the time. Caution: you may feel moved to get up and dance! (Received September 02, 2008)

1046-J1-436 **Reza Sarhangi*** (rsarhangi@towson.edu), Towson University, Department of Mathematics, 7800 York Building, Towson, MD 21252. *A Brief Study of Designs on the Surfaces of Some Swing-Hinged Dissections.*

By a dissection we mean, cutting a geometric, two-dimensional shape into pieces that one can rearrange to form a different shape. Examples of interesting and mathematically sophisticated dissections come from a wide range of resources, from the ancient Greeks, to the medieval period of Islamic art and science, to the mathematical puzzle columns in magazines, and to many website resources. A special property for some dissections is the ability to connect pieces by hinges in such a way that it preserves the transformation between two shapes by swinging one figure to another. The purpose of this presentation is to inspect the dissections' structures from a different point of view: Using the transferable surfaces to illustrate patterns and designs that are changeable in a meaningful and pleasing way along with the shapes of the dissections. (Received September 02, 2008)

1046-J1-461 **B Lynn Bodner*** (bodner@monmouth.edu), 623 Fawn Drive, Toms River, NJ 08753. *Recreating a Decagonal Star Polygon Design.*

How did artisans centuries ago create the beautiful geometric designs still found today on historic buildings and monuments throughout the Islamic world? There are few written records to definitively answer our question and it is quite likely that several different methods requiring practical geometrical knowledge were actually employed, including the use of traditional tools of the medieval period – the compass with a fixed opening (a "rusty compass"), straightedge, and set square – and there is also evidence that polygonal grids were used. In this presentation, we will illustrate E. H. Hankin's "polygons in contact" grid method for recreating a beautiful 10-pointed star polygon design. (Received September 03, 2008)

1046-J1-470 **JoAnne Growney*** (japoet@msn.com), 7981 Eastern Ave, #207, Silver Spring, MD 20910. *Playing with Poetry: using mathematics to discover new verses.*

In this presentation poet and former mathematics professor JoAnne Growney explores roles that mathematical structures and formulas can play in the creation of poems. Topics will include arithmetical patterns of counting syllables, substitution of new nouns as arguments in a poem-as-function, and application of the Fundamental Theorem of Arithmetic to generate lines of a poem from short phrases that play the roles of primes. Growney will offer examples that explore how mathematical processes can free a poet's imagination from his or her biases or other limitations. (This sort of activity looks back to the OULIPO movement of the 1960s, initiated by a group of writers and mathematicians in France, led by Raymond Queneau and Francois Le Lionnaise. OULIPO (acronym for "Ouvroir de Litterature Potentielle") describes a "Workshop of Potential Literature." Martin Gardner's writings in Scientific American helped to popularize the OULIPO movement in the United States.) Growney will conclude with a few remarks concerning how creation of a piece of mathematics compares with creation of a poem. (Received September 04, 2008)

1046-J1-540 **Jeff A Suzuki*** (jeff_suzuki@yahoo.com), Department of Mathematics, Brooklyn College, 2900 Bedford Ave., Brooklyn, NY 11210. *Cut My Cote: When Geometry Met Fashion.*

The width of a bolt of fabric is determined by the width of the loom. Consequently tailors must cut and piece garments from rectangles of fixed width and arbitrary length. To avoid wasting material, tailors throughout the millennia have adopted a number of strategies to cut the fabric that simultaneously minimizes waste while allowing them to produce more flattering garments. We will take a look at some of these strategies, which involve ideas from geometry that include tessellations, symmetry, congruence, and similarity. (Received September 09, 2008)

1046-J1-585 **Susan L. Ganter*** (sganter@clemson.edu), Dept of Mathematical Sciences, Box 340975, Martin Hall O-110, Clemson, SC 29634-0975, and **Joanne Caniglia** and **William Haver**. *The MAA Curriculum Foundations Project: A report from the workshop on mathematics and the arts and implications for the undergraduate mathematics curriculum.*

Since the 1950s, the MAA has had a major role in formulating recommendations concerning the foundational years in college mathematics instruction. Given the impact of mathematics instruction—especially instruction during the first two years—on other disciplines, there is a need for significant input from these colleagues to inform such recommendations. Much of this necessary information for the "mathematics intensive" disciplines has been gathered through a series of disciplinary workshops. These findings were published as Voices of the Partner Disciplines (Ganter and Barker, 2004) and contributed to MAA's national report on the undergraduate mathematics program (MAA, 2004). A second series of disciplinary workshops, focused on the social sciences and humanities, is now being conducted. This presentation will report on the results from the workshop on Mathematics and the Arts. Workshop participants included artists who express their work with mathematical themes and mathematicians who use artistry as a means of making the abstract concrete. The resulting report represents a consensus of artists, art educators, mathematicians, and mathematics educators on the mathematical needs of college-level students majoring in the arts. (Received September 08, 2008)

1046-J1-672 **Roger Bilisoly*** (bilisolyr@ccsu.edu), Department of Mathematical Sciences, CCSU, 1615 Stanley St., P.O. Box 4010, New Britain, CT 06050. *Which Edgar Allan Poe Story is His Most Quintessential? A Word Analysis Using Galois Lattices of Formal Concepts.*

The field of information retrieval has numerous measures of text similarity, for example, cosine similarity with weighted word counts. These, however, often require using vectors with thousands of dimensions. Unfortunately, high dimensional vector similarity is hard to link to how a human intuitively compares two literary texts. We apply an alternative approach that is based on formal concept analysis (FCA), which is used in machine learning and concept data analysis. Given two sets, one of objects, the other of attributes, there are algorithms such as Ganter's that find a finite lattice of subsets for both. These are linked by a bijection, and together are called a Galois lattice. This is applied to Edgar Allan Poe where his short stories are the objects, and the attributes are collections of words related by a common theme, for example, all the word forms of the synonyms of *horror*. Stories that are maximal with respect to attributes are defined to be quintessential. This presentation outlines how FCA works, and how to apply it to find Poe story clusters in the resulting Galois lattice. Finally, the results are compared to how a human perceives Poe's works. (Received September 09, 2008)

1046-J1-715 **Hayden Harker*** (haharker@vassar.edu). *Group Theory Art.* Preliminary report.

Students in an introductory abstract algebra course often struggle with the basic concept of a group. I present an art project I assigned to my students to help address this challenge in which they were asked to visualize a group in a medium of their choice. The resulting art was often pleasing to the eye and revealed elements of the structure of the depicted group. This assignment provided students with an opportunity to engage group theory in a manner that best suits their learning style, to see how other students engage the material and to surprise each other with their creativity. (Received September 10, 2008)

1046-J1-818 **Vicky Williams Klima*** (klimavw@appstate.edu), Department of Mathematical Sciences, Appalachian State University, Boone, NC 28608. *Using Music to Demonstrate Group Theory.* Preliminary report.

Students in an introductory modern algebra course often struggle with the abstract nature of the material in the course. The twelve-tone musical scale can serve as a familiar example of a cyclic group for many students. In this talk, I will discuss some ways of making group theoretic ideas such as subgroups, automorphisms, and quotient groups more concrete by looking at examples in the cyclic group of order twelve and playing these examples on a virtual keyboard. These examples will serve to demonstrate some interesting connections between basic group theory and basic music theory. I have had success using this material with audiences ranging from gifted high school students in a physical classroom to collegiate modern algebra students in an online environment. (Received September 11, 2008)

1046-J1-920 **Dale K Hathaway*** (hathaway@olivet.edu), One University Avenue, Department of Mathematics, Olivet Nazarene University, Bourbonnais, IL 60914. *Mathematical Photo Scavenger Hunt.*

A great activity for a math club is a mathematical photo scavenger hunt. Teams of students with digital cameras can be sent out across any campus to photograph mathematics. These photos can then be easily loaded into a computer and presented to the entire group. This activity encourages students to notice the mathematics that is all around us. This talk will provide a few suggestions for this type of activity and will present numerous examples of mathematical photographs. (Received September 12, 2008)

1046-J1-983 **Karen D. Ivy*** (kivy@njcu.edu), New Jersey City University, 2039 Kennedy Blvd, Jersey City, NJ 07305. *The Four R's in Math Education: Reading, WRiting, ARithmetic, and Rhyme.*

Many students who walk through the corridors of schools, colleges and universities find mathematics to be a difficult subject to learn. Variations in learning styles are often due to how successful a student has been in translating a new idea into a well-understood concept. Poetry can help a student make this connection. If one thinks of poetry as merely deep thought about a particular topic and the writer's innate ability to express those feelings, then one can understand how math educators may use poetry in mathematics to help students improve both their communication skills and math vocabulary. Students are encouraged to choose a topic and write about it using mathematical overtones or undertones. By marrying content, pedagogy, philosophy, and psychology, the speaker engages the students in learning mathematics and about themselves through poetry. (Received September 13, 2008)

1046-J1-1050 **Helmer Aslaksen***, Dept. of Mathematics, National University of Singapore, Singapore, 117543, Singapore, and **Aditya Liviandi**. *How long was Vermeer's studio?* 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. Unfortunately, most of the other sources do not explain their computations clearly. The results of our computation are not satisfactory, but we suspect that Vermeer may have manipulated the angle between the mirror and the wall. We also hope that showing our computations in detail will inspire other people to improve on them, and hopefully get more definite results. (Received September 14, 2008)

1046-J1-1180 **Olya V Sahakyan*** (annatdent@yahoo.com), 12 Charents taghamas, apt 11, Avan 3/2, Yerevan, Armenia. *On the beauty of mathematics.*

Throughout the history there has been a close contact between the art and science, often mediated through philosophy. The contemporary development level of mathematics, its wide penetration into all aspects of life inevitably proves the important role of this science. Science, similar to art multiplies knowledge about life, enlarges the spiritual horizon of man. Its purpose is to analyze life to find its laws, to discover the harmony of the universe and thus to contribute to progress in the world. How should the instruction of mathematics engage the students into learning? Mathematics attracts with the logical order of the regularities, clearness of proofs, laconic language, meaningful symbols, universality of the obtained results, latitude of generalizations, penetration into various fields of knowledge and practical human activity. Students discover the beauty of math when they encounter a problem that forces them to use previously mastered knowledge and requires observation, consideration, and creative thinking at the same time. Starting from the age of 6-7 it is necessary to form the idea about the beauty of mathematics in students. Subsequently, every time studying mathematics and mastering research methods, they are convinced that mathematics possesses internal beauty. (Received September 15, 2008)

1046-J1-1396 **John F. Putz*** (putz@alma.edu), Mathematics and Computer Science Department, Alma College, 614 W. Superior St., Alma, MI 48801. *The Golden Ratio in the Arts: A Skeptic's Inquiry.*

It's easy to get carried away: Leonardo, Mozart, navels, pretty rectangles. Beginning with a cautionary theorem, we'll establish a criterion for acceptance of a golden ratio relationship, then test some claims for the presence of the golden ratio by looking at some well-known paintings and sculptures, some data collected by my students, and the results of a study and an experiment of my own design. (Received September 15, 2008)

1046-J1-1596 **Barbara Ashton*** (bashton@bmcc.cuny.edu), BMCC, Room N539, 199 Chambers Street, New York, NY 10007. *Modeling Heraldry using Shape Grammars.* Preliminary report.

Heraldry is both a social code and a system of charges and tinctures that are arranged on shields. The rules of heraldry form a type of grammar called blazon. The precise rules and strict composition of blazon can be modeled using a shape grammar, a collection of functions defined on shapes. The definitions of the shapes and functions will be described and used to generate unique shield designs. (Received September 16, 2008)

1046-J1-1600 **Patrick Bahls*** (pbahls@unca.edu), Department of Mathematics, UNC Asheville, CPO #2350, One University Heights, Asheville, NC 28804-8511. *Potential literature and group theoretical poetry.* Preliminary report.

Historically the intersection of math and poetry is not an empty one. Leaving aside classical mathematical prescriptions for poetic structure (meter, rhyme structure, syllable count), modern literature has seen poetry and other experimental literary forms imbued with much more intentional mathematical structure.

In this talk we will briefly survey the work of the "potential literature" movement and associated movements. We will then indicate some new methods for crafting poetry with structures prescribed by group theory. These methods are interesting not only as guides for literary invention, they serve as excellent pedagogical tools assisting the teaching of various topics in abstract algebra. (Received September 16, 2008)

1046-J1-1680 **Douglas E Norton*** (douglas.norton@villanova.edu), Dept. of Mathematical Sciences, Villanova University, 800 Lancaster Avenue, Villanova, PA 19085. *Parameters, Patterns, and the Phase Plane.* Preliminary report.

The phase plane provides a standard visual representation of some qualitative properties of solutions of systems of differential equations modeling two interacting populations. A phase portrait is traditionally used to represent related solutions of a particular system of equations. In this preliminary report, we investigate the graphical representation of solution curves of systems close in parameter space that share common initial conditions. In these simple preliminary examples, the patterns and information they carry differ from the usual phase diagrams and suggest potential for further aesthetic investigation as well as dynamical information. (Received September 16, 2008)

1046-J1-1707 **Michelle Y Penner*** (pennerm@cvcc.vccs.edu), Central Virginia Community College, 3506 Wards Road, Lynchburg, VA 24502-2498. *Newton and Fibonacci: Estimating The Golden Ratio.*

This talk starts with an overview of some of the historical and cultural occurrences of Fibonacci numbers and the golden ratio. The second part of will prove that in using Newton's Method to estimate the golden ratio, if the seed is a ratio of adjacent Fibonacci numbers, then the resulting estimate is again a ratio of adjacent Fibonacci numbers. (Received September 16, 2008)

1046-J1-1754 **James R Hughes*** (hughesjr@etown.edu), Elizabethtown College, Elizabethtown, PA 17022, and **Brandon Metz**. *Modeling Voice-leading in Music: The Special Role of the Bass Voice.* Preliminary report.

Recent work in mathematical music theory proposes various models for measuring efficiency of voice-leading in polyphonic music. In many tonal contexts, the bass (lowest) voice has a special role in shaping harmonic structure, which creates additional constraints in voice-leading problems. We report on an undergraduate senior thesis project that explores the effect of such constraints on measures of voice-leading efficiency. (Received September 16, 2008)

1046-J1-1908 **Darrah P. Chavey*** (chavey@beloit.edu), Beloit College, 700 College St., Beloit, WI 53511. *Symmetry Groups of Chokwe Sona Drawings.* Preliminary report.

The Sona drawings of the Chokwe people of Angola/Zaire are a particularly attractive form of “mirror curves,” visualizable as a ball bouncing through an arrangement of dots, bouncing off “mirrors” placed between some of the dots, and leaving a closed trail behind. Unlike some other drawing traditions, these mirrors are always placed on the perpendicular bisector to a line connecting two closest points. The Chokwe artistic aesthetic strongly prefers mirror curves that: separate each dot in a grid from the others, generate an Eulerian circuit, and are highly symmetric. To investigate some of the possibilities for such Chokwe Sona, we classify the rectangular arrays of dots which can generate cyclic or dihedral central symmetry groups, show that all but the smallest rectangles allow for the construction of Sona with any of the seven linear symmetry groups, and begin an investigation into the realizable 2-dimensional symmetry groups for such Sona. For central symmetry groups, the symmetries can be exact, while for the linear and wallpaper symmetry groups, boundary modifications are required to close the Eulerian curves, while maintaining the symmetry group on the primary part of the Sona. (Received September 16, 2008)

1046-J1-1926 **Kurt E Ludwick*** (keludwick@salisbury.edu), 23557 Taylors Trail, Mardela Springs, MD 21837. *A Mathematics & Music Course for Liberal Arts Majors.*

In this talk, I will discuss a course I piloted in Fall, 2008 for non-science majors on the mathematics of music. While there was no true textbook for this course, we loosely followed Leon Harkleroad's text, ”The Math Behind the Music.” Through exploring musical topics including pitch, intervals, chords, alternate tunings of the keyboard and variations on musical themes, students with very a limited mathematical background were exposed to mathematical concepts ranging from exponents and logarithms to basic group theory.

I will discuss the successes and shortcomings of the first run of this course, providing examples of handouts and assignments to illustrate what worked well and what may need to be revised (or dropped altogether, as the case may be). As this was a first attempt, audience suggestions and feedback will be most welcome! (Received September 16, 2008)

1046-J1-1965 **Douglas Dunham*** (ddunham@d.umn.edu), Department of Computer Science, 320 HH, 1114 Kirby Drive, Duluth, MN 55812-3036. *The symmetry of M.C. Escher's* Circle Limit IV *pattern and related patterns.* Preliminary report.

M.C. Escher created four patterns in the Poincaré model of hyperbolic geometry. The last one, *Circle Limit IV*, is an alternating pattern of angels and devils. Escher previously drew a Euclidean pattern of angles and devils as Notebook Drawing 45 and carved a maple ball with that pattern on its surface. The symmetry group of Notebook Drawing 45 is generated by a reflection across the body axis of an angel or devil and a 4-fold rotation about one of its wing tips. This symmetry group is denoted $[4^+, 4]$ in H.S.M. Coxeter's notation, and 4*2 in orbifold notation. On the maple ball some of the angels are indented relative to their surrounding devils, and vice versa. If this indentation is ignored, the symmetry group is $[3^+, 4]$ or 3*2, otherwise it is just the dihedral group D_2, with two perpendicular reflection planes through the poles. In *Circle Limit IV*, some angels and some devils are only outlined. Close inspection reveals the symmetry of the pattern to be just the dihedral group D_3, with three reflection lines through the center. If all the outlines were filled in, symmetry group would be $[4^+, 6]$ or 4*3. By filling in some outlines, and unfilling others, we can obtain other hyperbolic patterns with more interesting symmetry. (Received September 16, 2008)

1046-J1-1997 **Michael P. Saclolo*** (mikeps@stedwards.edu), 3001 South Congress Avenue, Austin, TX 78704. *How a medieval troubadour became a mathematical figure.* Preliminary report.

In an instance of art inspiring mathematics we shall see how a poetic form has influenced modern mathematics. This form, with its origins in the Middle Ages and invented by a troubadour, led to modern research in permutation groups and finite fields. Consequently many of the mathematical objects involved are named after literary figures from both medieval and modern times. (Received September 16, 2008)

1046-J1-2018 **Stephen H. Harnish*** (harnishs@bluffton.edu), Bluffton University, 1 University Drive, Bluffton, OH 45817. *Art from the Margins: Questions raised by artistic patterns illustrating FLT.*

Excel spreadsheets will illustrate the moduli of initial and middle sums of a few key sequences, especially those of the form $\{(k+1)^n - k^n\}$ for $k = 0, 1, 2, \ldots$ Many of the resulting patterns exhibit order, symmetry and subtle artistry while also prompting mathematical questions appropriate for undergraduate research and some visual insight into special cases of Fermat's Last Theorem. From such explorations emerges a final question: "For Fermat, just how wide of a margin might have sufficed?" (Received September 16, 2008)

1046-J1-2021 **Michelle Krolikowski*** (jkrolikowski0713@lions.piedmont.edu) and **Elizabeth C Rogers** (brogers@piedmont.edu), 4733 Highland Road, Gainesville, GA 30506. *Mathematics of Southern Appalachian Folk Pottery.*

Folk pottery from the southern Appalachian area of the United States is rich in history, practical application and mathematics. Although the mathematics is not explicitly stated in any reference book, it is interwoven into almost every step of the process from the production of the potter's wheel to the importance of measurement and time. The finished products exhibit various symmetries and geometric transformations. As each facet of this art form is explored, the mathematics involved will concurrently be explored and explained. On completion of this journey, one will understand why folk pottery is highly valued by collectors and museums for its significant historical relevance, its beauty and uniqueness as well as its mathematical implications. (Received September 16, 2008)

1046-J1-2068 **Zdenka Guadarrama*** (guadarrama@rockhurst.edu), 1100 Rockhurst Road, Kansas City, MO 64110. *Complex Visualizations and Sculpture: An interdisciplinary project for undergraduates.* Preliminary report.

Undergraduate Complex Analysis students reinforce their abstract understanding through visualizations that result in very esthetically pleasing graphs. These graphs are then used to create sculptures. I will show examples of visualizations generated in Mathematica and their transition from drawings to sculpture. By seeing the implicit mathematical structure in the sculpture we gain a greater understanding of the creative process and the mathematics behind it. (Received September 17, 2008)

Mathematics of Games and Puzzles

1046-L1-23 **Bill Marion*** (Bill.Marion@valpo.edu), Dept. of Mathematics and Computer Science, Valparaiso University, Valparaiso, IN 46383. *Using the Pile Splitting Puzzle to Enhance Student Learning of Mathematics.*

Pile Splitting Puzzle: Split a pile of N objects into two smaller piles. Continue until there are N piles of size 1. At each splitting multiply the sizes of the two split piles. Then, add the N-1 products. The result will always be the same no matter how the piles are split and will be a function of N. The author first became acquainted with this puzzle in an article by James Tanton in the September 2004 issue of Math Horizons. Subsequently, he found the puzzle presented as an exercise in Kenneth Rosen's 5th edition (2003) of his discrete math text. Though their solutions were the same, each used a different argument to prove the solution correct. (Tanton, also, described a number of variants, each involving different computations.) In this paper the author will describe and illustrate the puzzle using a pile of beads and present the solution along with both proofs. More importantly, he will discuss ways in which he has used this puzzle and its many variants to help students find patterns, make conjectures and develop coherent proofs*as an in-class activity, an out-of class group project, a computer programming project and an undergraduate research project. (Received June 08, 2008)

1046-L1-330 **Andrew G Niedermaier*** (aniederm@math.ucsd.edu), 9500 Gilman Drive, La Jolla, CA 92093-0112. *Meet Colonel Blotto.*

Meet Colonel Blotto, master tactician of the battlefield. His problem is a doozy: apportion 100 soldiers to fight at 10 different castles. The opposing also has 100 soldiers, and the larger army at each castle will claim victory. Should Blotto send 10 soldiers to each castle, or perhaps should he focus his efforts on a subset of the 10?

Well, it depends. Are the castles equally valuable? What happens when 100 people play each other pairwise? What happens when two armies face each other multiple times – do they change their strategies from one skirmish to the next?

The enormous potential for variations to the basic rules makes Blotto an excellent entree to the ideas of repeated play, strategic thinking, and apportionment. Blotto makes for a fun classroom diversion inbetween lessons, but it can just as easily serve as the focus of an in-depth discussion of core game theory concepts. I've had success playing Blotto with junior high students, high school students, and college calculus lectures.

I will introduce the basic rules, highlight some interesting variations, and describe how a game of Blotto can be quickly run using an Excel spreadsheet. And of course, I will invite the audience to participate in a friendly all-play-all Blotto game. (Received August 26, 2008)

1046-L1-374 **Heakyung Lee*** (leeh@winthrop.edu), Dept. of Mathematics, Wintrop University, Rock Hill, SC 29732. *Magic Tortoise Puzzles.* Preliminary report.

A maic tortoise using numbers 1 through 30 was developed by a Korean scholar in the 17th century. Each hexagon in the magic tortoise has a sum of 93. Other magic tortoise using the same numbers with a different sum will be shown. Several types of a modified tortoise puzzle will be also introduced. (Received August 28, 2008)

1046-L1-412 **Homeira Pajoohesh** and **T. Bruce McLean*** (bmclean@georgiasouthern.edu), 19 Northlake Dr., Statesboro, GA 30458, and **Thomas Anderson**, **Chasen Smith**, **Emil Iacob** and **John Nelson**. *Counting the Mathematical Faces of All Regular Flexagons.* Preliminary report.

Three faculty joined with three students over the last two years to study regular flexagons. Regular flexagons are constructed from straight strips of paper consisting of equilateral triangles and were discovered in 1939 by Arthur Stone when he was a graduate student at Princeton University. It is well known that a regular flexagon of order 3n, $n > 0$, contains 9n equilateral triangles, and is a mobius band with 3 (3n - 2) half-twists. If only the pinch flex is used it is also known that there are 6n - 3 different mathematical faces. In 1979, with the discovery of the V-flex, the flexagon of order 6 was shown to have 3420 mathematical faces. It is the purpose of this paper to demonstrate an algebraic algorithm that counts the number of mathematical faces for flexagons of order 3n for every natural number n. (Received September 01, 2008)

1046-L1-507 **Ryan Mullen*** (mullenr@sacredheart.edu), 32 Thomas Dr, Manchester, CT 06040. *On determining Paint by Numbers puzzles with non unique solutions.* Preliminary report.

Paint by Numbers is a classic logic puzzle in which the squares of an $n \times m$ grid are to be colored in such a way to display a picture. The decision on which squares to color is determined by sequences of numbers to the left of each row and above each column. The numbers describe how many consecutive squares are to be colored in that row or column, multiple numbers represent multiple blocks of colored in squares (with at least one uncolored square in between blocks.) Certain natural questions arise. For a given $n \times m$ grid how many possible sequences are in a single column or row? For a given grid how many puzzles are there? How many of these have unique solutions? We will explore these questions as well as connections between Paint by Numbers puzzles, partition theory, and the Fibonacci sequence. (Received September 05, 2008)

1046-L1-619 **Roman Wong*** (rwong@washjeff.edu), Mathematics Department, Washington and Jefferson College, Washington, PA 15301, and **Shunika Hamilton** (hamiltonss@washjeff.edu) and **Sarah Charley** (Charleysr@washjeff.edu). *The Alarm-Off puzzle.*

A security system consists of a row of n switches that can be toggled on or off one at a time governed by the following rules: (1) Switch 1 can be toggled at any time. (2) To toggle switch k, switch k-1 must be on and switches i must be off for all i<k-1, if any. The switches are all on at the start. The puzzle is to determine the minimum number of toggles needed to turn off all the switches. This one-dimensional puzzle is then extended to two dimensions with rectangular and triangular configurations. (Received September 09, 2008)

1046-L1-740 **Eric W Drake*** (eric.drake@usma.edu), Department of Mathematical Sciences, United States Military Academy, West Point, NY 10996, and **Robert E Burks Jr** (robert.burks@usma.edu), Department of Mathematical Sciences, United States Military Academy, West Point, NY 10996. *Rubik's Cubes in the Classroom: How a Puzzle of Logic, Patterns, and Algorithms Can Build Confidence in Mathematics.*

Incoming freshmen at The United States Military Academy are screened and evaluated via a combination of SAT Scores, math performance in High School, placement exams, and time since last math course. This screening places students in the core, the advanced, or the developmental mathematics curriculum. Each year, approximately 5% of incoming freshmen are placed in the developmental mathematics curriculum. This curriculum combines precalculus with "just in time" mathematical modeling and introduction to calculus to prepare the student for the rest of the core math curriculum and the engineering classes they will encounter at West Point. Many of the students in the developmental program have problems with their confidence in mathematics and being placed in a "developmental" mathematics class can be very deflating. In an effort to nurture creativity, critical thinking and to boost confidence, we have introduced the Rubik's Cube into the classroom. We will discuss our findings of how teaching the Rubik's Cube to cadets in the developmental math program has positively impacted their confidence, their learning, and their overall performance at the United States Military Academy.
(Received September 10, 2008)

1046-L1-801 **James Z Klingensmith*** (klingensmithjz@washjeff.edu), Washington and Jefferson College, Washington, PA 15301, and **Roman Wong** (rwong@washjeff.edu), Washington and Jefferson College, Washington, PA 15301. *La Loubere magic squares.*

If you are interested in magic squares, you know about the La Loubere's staircase method for constructing odd ordered magic squares. However, there are not many references that show why the method works. We use cosets and a recent result on transversals in matrices to show why this method always results in a magic square. Furthermore, we also show that the starting number 1 in this method needs not be at the center square of a border. (Received September 11, 2008)

1046-L1-891 **Donald E. Hooley*** (hooleyd@bluffton.edu), Mathematics Department, Bluffton University, Bluffton, OH 45817. *Elementary Farkle Strategy: Have You Farkled Lately?*

Farkle is played by throwing six dice, retaining scoring dice and then choosing whether or not to throw the remaining dice. If no points are scored on a throw the player is said to "farkle" and loses all points accumulated on that turn. We illustrate calculation of average scores and the probability of farkling on a given throw, questions appropriate for undergraduates in introductory probability and programming courses. Then we investigate a possible model for an elementary playing strategy optimizing turn score and indicate directions for additional student study. In addition, we present suggestions for computer simulation modeling the multi-step playing process and examples of preliminary results. (Received September 12, 2008)

1046-L1-1135 **Matthew M Burke*** (mmburke@gwu.edu), 801 22nd St NW, #709, Washington, DC 20052. *Two-Dimensional Abstract Games.*

An impartial game can be described as one or more piles of beads. The game's rules specify how many beads can be removed from a pile and whether splitting a pile into two (or more) piles is allowed. A pile is assigned a value indicating which player will win under best play. Values for a game of multiple piles are determined as a function of the values of the individual piles. There is a natural order for listing the values for different size piles for a game. This sequence of values, the Grundy Sequence, characterizes each impartial game.

Piles of beads in an impartial game have no internal structure. If the rules allow removal of two beads from a pile, it does not matter which two are removed. I define a two-dimensional impartial game by specifying a spatial structure for the piles: in addition to specifying how many beads can be removed from a pattern, the rules specify constraints on which beads may be removed. For example, a rule might stipulate that two beads can be removed only if they are next to each other.

Spatial patterns do not have a natural ordering, thus an analog for the Grundy Sequence must be developed. This paper describes initial work to find such an analog. A number of open questions, accessible to undergraduates, are raised. (Received September 14, 2008)

1046-L1-1378 **Thomas C. Hull*** (thull@wnec.edu), Dept. of Mathematics, Box H-5174, Western New England College, 1215 Wilbraham Rd, Springfield, MA 01119. *You Gotta Know How to Fold 'Em.*

Given a crease pattern on a piece of paper which we know can fold flat, is there any way of enumerating the number of ways in which the creases can all be folded flat? That is, how many valid mountain-valley assignments are there for the creases? The fact that this is generally a very difficult – and quite open – question has resulted in a number of interesting folding puzzles. For example, crease patterns that admit only a few ways to be folded can be very challenging to collapse. In this talk we will examine some of the combinatorics behind this general problem, from the very well-understood single-vertex case to more challenging classes of larger crease patterns. (Received September 15, 2008)

1046-L1-1836 **Darryl K Nester*** (nesterd@bluffton.edu), Bluffton University 52, 1 University Drive, Bluffton, OH 45817. *Using Game Theory to Get a Date: Strategy Selection for Two (or more) Suitors.*

Every day, Ann arrives home from work at some (random) time A between 4:00 and 5:00, and goes out to eat at 5:00. Bill and Carl would both like to take Ann to dinner. Sadly, at the end of each day, both of their cell phone batteries are depleted, so that each can only make one call between 4:00 and 5:00. If Bill calls at time B and Carl calls at time C, Bill gets the date if either $A < B < C$ or $C < A < B$. (If both call before Ann arrives home, everyone dines alone.) We'll help Bill choose a calling strategy to maximize his chance of getting a date no matter how Carl chooses a calling time. Then we'll consider what happens if—unbeknownst to Bill and Carl—a third suitor joins the game. (This problem is adapted and extended from *Statistical Decision Theory and Bayesian Analysis* by James Berger.) (Received September 16, 2008)

1046-L1-1840 **Daniel Schaal*** (daniel.schaal@sdstate.edu), Dept. of Mathematics and Statistics, South Dakota State University, Brookings, SD 57007. *Should you take the bet? A problem from Marilyn Vos Savant.*

In this paper we analyze a coin showing game that appeared in the "Ask Marilyn" column in Parade Magazine, a column written by Marilyn Vos Savant. This simple game illustrates some of the basics of game theory but has some unusual and interesting twists. It is also not clear if Marilyn was right or wrong in her answer. Note, this talk is NOT about the "Monte Hall Problem" which was made famous in the same column. (Received September 16, 2008)

1046-L1-1989 **Alex Meadows*** (ammeadows@smcm.edu), Department of Mathematics, SMCM, St. Mary's City, MD 20686-3001. *Chomp, chomp, bechewy chomp: research with undergraduates.* Preliminary report.

We describe David Gale's game of Chomp and a research project with first-year undergraduates. We also discuss two interesting generalizations of Chomp developed by undergraduates and recent work on Chomp on the Boolean lattice. (Received September 16, 2008)

1046-L1-1993 **Doug Ensley*** (deensley@ship.edu). *Leapin' lizards! It's mathematics!*

The Leapin' Lizards puzzle by Binary Arts is a peg solitaire game consisting of five chameleons that must all make their way home from an initially scrambled state among six available pegs. The catch is that they must follow pathways (read *graphs*, mathematicians) defined by cards placed over the game board. The puzzle has the added benefit of being adaptable to a "paper and pencil" version for classroom use, no doubt to the chagrin of Binary Arts. In this talk we will discuss mathematical models for this puzzle as well as criteria by which the manufacturer has rated the difficulty of each card. (Received September 16, 2008)

1046-L1-2049 **Charles Andrew Tannouri*** (Yagno2000@gmail.com). *Be Rational! An Examination of Player Motives and Utility.* Preliminary report.

In game theory, a rational player is defined to be one who acts to maximize his or her utility. However, a player often makes decisions which seem counterintuitive to the goal of maximizing utility. When rational decisions are not taken, two factors must be taken into account. First, the motivations for making an irrational decision must be weighed against the benefit of an optimal strategy. Second, a player's understanding and awareness of the optimal strategy must be assessed.

The actions and interactions of such players will be examined and compared to optimal strategies per the concepts of game theory. This analysis will then be used to discuss the fundamental question of whether or not games are a reasonable predictor of many aspects of human life such as economics, job competition, and social interaction. The applications of such a model will be expanded upon and applied to the discussion of the spread of disease as a zero-player game, a two-player game, or an n-player game. (Received September 16, 2008)

Mathematics Experiences in Business, Industry and Government

1046-M1-443 **George V Woodrow III*** (georgevw3@mac.com), 647 Primrose Lane, River Vale, NJ 07675-6511. *Effective use of Controls in the Clinical Laboratory : Analysis of Traditional and new Algorithms.*

The primary means of determining the quality of testing in the clinical laboratory is the analysis of control results. Traditional Quality Control (QC) uses a set of pass/fail rules applied to a limited number of control results. This presentation provides a mathematical analysis of the performance of these rules, highlighting their suitability for use in an automated laboratory, and for meeting modern quality goals. As a result of this analysis, new algorithms and techniques for the analysis of control results have been developed and tested. These new algorithms will be presented. (Received September 03, 2008)

1046-M1-559 **Michael G Monticino*** (monticino@unt.edu), University of North Texas, P.O. Box 305189, Denton, TX 76203. *Least Cost Check Routing.* Preliminary report.

A check must be presented to the bank upon which it was drawn in order for that check to clear. Up until 2003, this meant presenting a physical piece of paper. Every night hundreds of millions of pieces of paper criss-crossed the country as air carriers transferred checks from one bank to another. A massive break-down of the check clearing process occurred after 9/11 when all air traffic was grounded for three days. This motivated Congress to pass the Check Clearing for the 21st Century Act. The law allows a substitute electronic document to serve as a legal equivalent of the original (paper) check. Electronic-based check clearing allows the opportunity to use dynamic optimization techniques to route checks through the least cost clearing options. This talk will discuss analytical methods to optimally allocate checks to available clearing options to minimize cost to the sending institution. Clearing costs involve per item fees, cash letter fees, and losses from the clearing service float. Challenges to the optimization process include multiple clearing options with dynamic fee schedules, millions of checks that must be cleared in a given time window and the uncertainty of check volume throughout a day. This work is being conducted with ARGO Data Resources Corporation. (Received September 08, 2008)

1046-M1-667 **Richard D Jarvinen*** (rjarvinen@winona.edu), Mathematics and Statistics Department, 308 Gildemeister Hall, Winona, MN 55987. *Reliability as a Field in Aerospace: A NASA Application.*

In virtually each year since 1995, the author–and professor–has worked (full or part time) as a Research Scientist Consultant for the NASA Johnson Space Center in Houston, Texas, centering his work on risk and reliability assessments for the Space Shuttle program. In this talk, insight into the field of reliability per se and its application in the Space Program will be presented, largely through use of an example showing a reliability method (for zero-failure testing models) to assess the reliability of an important instrument designed for use on the International Space Stattion. (Received September 09, 2008)

1046-M1-757 **David Joyner***, Math Dept, Chauvenet Hall, US Naval Academy, Annapolis, MD 21402. *A short B.I.G. introduction to Sage.*

This talk will discuss how the Sage mathematics software package is developed, along with the mathematics included in it, with an emphasis on applied mathematics. (Received September 10, 2008)

1046-M1-973 **Paul H Schuette*** (schuettep@gmail.com). *A Mathematical Consideration of the Rule of Three.* Preliminary report.

Researchers involved in clinical trials will sometimes employ a rule of thumb known as the "Rule of Three." Basically, the Rule of Three states that if no adverse affects have been observed in n trials, then the probability of an adverse effect should be no more than 3/n. An alternative formulation of the Rule of Three is that if an adverse event has probability p of occurring, we would need a sample of size 3/p to be reasonably assured of observing at least one occurrence. It will be shown that the Rule of Three can be derived from an approximation to a binomial distribution, and discuss an alternative derivation using a Poisson distribution. We shall also discuss the ease and appropriate use of the Rule of Three as well as some limitations. (Received September 13, 2008)

1046-M1-1230 **William P Fox***, Department of Defense Analysis, Naval Postgraduate School, Monterey, CA 93943. *Dynamical Systems Modeling for Iraq.* Preliminary report.

Modeling was used to gain insights in the three-circle diagram of the Iraq war. We created a dynamical system's model, the INFORM model, that included many variables representing not only the infrastructure elements. Five small preliminary scenarios were built to help gain insights into gaining stability in Iraq. This talk will present the model and several "what if" scenarios that were used. (Received September 15, 2008)

1046-M1-1312 **Mike P O'Leary*** (moleary@towson.edu), Department of Mathematics, Towson University, Towson, MD 21252. *Determining an Optimal Search Area for a Serial Criminal.*

The geographic profiling problem in criminology is to determine a search area for an offender based on knowledge of the offenders crime locations. We describe a new mathematical method for this problem that is able to incorporate geographic and demographic features that influence the selection of a crime site and uses Bayesian methods to generate its predictions. We will present the software tool that we are developing for police agencies to solve this problem and give examples of its use. (Received September 15, 2008)

1046-M1-1487 **James P Ochoa*** (ochoa@metsci.com), 11911 Freedom Drive, STE 800, Reston, VA 20190. *Using Mathematics in Industry.*

Abstract The purpose of this presentation is to describe working as a mathematician at Metron, Inc. Metron, a scientific consulting company located in Reston, Virginia, employs mathematicians, physicists, computer scientists, and engineers. An overview of Metron will be followed by a description of some of the projects on which I have worked. Specific examples of how I have used mathematics to solve real world problems will be presented. One such example involves using a Poisson process to model mean time between failures for a system, showing the limitations of classical statistical approaches and using Bayesian techniques as a workable alternative. Another example involves mapping uncertainty in ocean climatology for a large portion of the ocean. The talk will conclude with a brief description of how I came to work at Metron, what I did that prepared me for this work, and what I would suggest to anyone considering working in industry. (Received September 15, 2008)

1046-M1-1556 **Edmond Nadler*** (enadler@emich.edu), Department of Mathematics, Eastern Michigan University, Ypsilanti, MI 48197. *Mathematical Surface Modeling Problems in Industry.*

The speaker has done research and development in surface modeling in industry, primarily with B-spline based surfaces known as NURBS. In this talk, he will present some background and a few examples of such problems, which include: a swept surface, an n-sided patch, a blend surface, and efficient point cloud projection to a collection of surfaces. (Received September 16, 2008)

1046-M1-1671 **John E. Gray*** (john.e.gray@navy.mil), Code Q-23, Electromagnetic & Sensor Systems Dept, 18444 FRONTAGE ROAD SUITE 328, Dahlgren, VA 22448-5161. *The Doppler Effect in Radar as a Source of Mathematics.*

The Doppler Effect in physics has a rich history in physics dating back over a 150 years. The final resolution of the underlying explanation for the Doppler Effect lies in Special Relativity for objects moving at constant velocity. For objects moving at a non-uniform rate, the physically correct explanation requires general relativity. The perfect model for understanding the Doppler effect in radar is model of a moving mirror which can be used to understand the effect of motion on radar waveform. The functional form of radar return signal due non-uniform motion allows one to analyze the effect of target motion on the received signal. There has been a great deal of mathematics developed under the domain area of the "signal analysis" in electrical engineering that has lead to advances both in pure and applied mathematics. Wavelet theory and time-frequency methods are examples. In our talk, we briefly illustrate all of this. By demonstrating what the effect of non-uniform motion is on radar waveforms, we illustrate a resulting functional equation. This functional equation suggests several new approaches to thinking about how to represent information in physical signals which we discuss. We illustrate how this is connected to physical wavelets. (Received September 16, 2008)

1046-M1-1682 **James H Fife*** (jfife@ets.org), Mail Stop 11-R, Educational Testing Service, Princeton, NJ 08541. *A measure of inter-rater reliability when one rater is rating on a continuous scale.*

Cohen's kappa is a measure of inter-rater reliability that factors out chance agreement. The usual kappa assumes both raters are rating on a discrete scale. This talk presents a generalization of kappa to the case in which one of the raters is rating on a continuous scale. This measure is applied to data consisting of one human score and one automated score for each response in a set of responses to constructed-response test questions, where the human scores are on a discrete scale and the automated scores are on a continuous scale. Results of the analysis are discussed, including indications of conditions under which continuous scores will give more information than discrete scores. The continuous kappa can also be used to define a confidence measure for the automated score. (Received September 16, 2008)

1046-M1-1805 **Joni E. Baker*** (joni@va.wagner.com), Daniel H. Wagner Associates, 2 Eaton St., Suite 500, Hampton, VA 23669-4054, and **C. Allen Butler**, **W. Reynolds Monach** and **Thomas R. McSherry**. *Automated Torpedo Classification and Alerting Using Bayesian Methods.*

In this talk, we describe the use of advanced and automated Bayesian inference techniques used for target classification and prioritization within Daniel H. Wagner Associates' Anti-Torpedo Data Fusion and Optimization System (ATDOS), which we are developing for the Office of Naval Research. The ultimate goal is to utilize all relevant fused acoustic and non-acoustic sensor data to reduce the false alarm rate drastically, while maintaining a high probability of detecting any incoming threat torpedoes in a timely manner. Broadly speaking, the classification/prioritization process involves two main steps: first, our Non-Gaussian Data Fusion System (NGDFS) combines the available sensor data (e.g., active/passive sonar, radar, electro-optical) to form tracks, along with their associated kinematic and non-kinematic feature estimates. Then, our Bayesian Inference Engine (BIE) uses these feature estimates, as well as the associated sensor data, to calculate the probability that each track is a torpedo. In this talk we will focus on the BIE, the underlying Bayesian Network for ATDOS, and the logic by which evidence is incorporated therein. We will also provide an analysis of the ATDOS's performance during a very successful live torpedo demonstration which took place in January 2008. (Received September 16, 2008)

Mathematics and Sports

1046-N1-39 **Jacqueline Brannon Giles*** (jbgiles@yahoo.com), 13103 Balarama Drive, Houston, TX 77099. *Take a Good Look, using Mathematics.* Preliminary report.

A study of the career statistics of selected NFL wide receivers(e.g. Jerry Rice and Warren Wells) will be accomplished using model building and calculus. A discussion of the robustness of the data, and some insight on the analysis of sports data will be done.

The presenter is a member of MAA, NAM and the Professional Football Researchers Association (PFRA). She has collaborated with a PFRA senior researcher to write an article inspired by a calculus classroom project conducted at HCC Central College, in Houston, Texas. (Received June 26, 2008)

1046-N1-53 **Stanley Rothman*** (Stanley.rothman@quinnipiac.edu), Stanley Rothman , Ph.D, 15 Stacy Ct., Cheshire, CT 06410. *Mission Impossible - Hitting .400 for a Season.*

From 1876 until today, the batting average has been considered the "gold standard" for judging a player's performance as a batter. Attaining a batting average of at least.400 is considered one of the great batting feats in baseball.This paper will look at the following four statistics: Batting Average = #Hits/#at bats; In-Play Batting Average = #Hits/(#at bats - #strike outs); Strike-Out Average = #strike outs/#at bats; In-Play Home Run Average = #home runs/(#at bats - #strike outs). This paper will explore relationships between these four statistics, compare these four statistcs for the years 1913-2007, compare the .400 hitters since 1913, define a true .400 hitter and discuss what it takes to bat.400 today. These issues and questions will be analyzed through the use of both descriptive statistics and inferential statistics. Summary measures and graphs will be used for comparisons. Linear regression and corrselation will be used to show relationships. The two techniques of confidence intervals and hypothesis testing will be used to estimate a player's true batting average and evaluate whether a player is a true .400 hitter. Simulations will be done using a spinner on a disk. (Received July 11, 2008)

1046-N1-128 **C. W. Groetsch*** (charles.groetsch@citadel.edu), School of Science and Mathematics, The Citadel, Charleston, SC 29409-6420. *Fixed Points and Free Throws.*

P.J. Nahin (When Least is Best, Princeton University Press, 2004, pp. 158-171) applies Halley's gunnery rule to minimal-energy, nothing-but-net free throws. For low velocity trajectories, as in basketball free throws, linear resistance is a reasonable model. We derive analogs of Halley's results for a linearly resisting medium. The analysis relies on implicit relationships connected with a simple fixed point problem and leads to a computable characterization of the launch angle leading to a minimal energy shot. (Received July 31, 2008)

1046-N1-210 **Mike Huber*** (huber@muhlenberg.edu), Dep't of Mathematics and Computer Science, Muhlenberg College, 2400 Chew Street, Alentown, PA 18104, and **Gabriel Costa**, **John Saccoman** and **Brandon Stern-Charles**. *Modeling Cumulative Home Run Frequencies and the Recent Home Run Explosion.*

In this presentation we define a measure which we call the cumulative home run ratio. We consider all baseball sluggers who have clubbed at least 400 career home runs and compare their cumulative home run ratios by the slugger's corresponding age. Virtually all power hitters have shared the same graphical trends as the batters enter their late 20s / early 30s ... until recently. The home run explosion over the past ten years has generated many questions spanning quite a few areas. How can such players hit home runs with such frequency so late in their careers? Is the pitching that much worse? Are other factors involved? In this presentation, we will explain our model and offer some predictive measures which can be used in the classroom for comparing the great sluggers, past and present, of the National Pastime. (Received August 19, 2008)

1046-N1-613 **T. S. Michael*** (tsm@usna.edu), Mathematics Department, United States Naval Academy, Annapolis, MD 21402. *Mathematics and Collegiate Wrestling Tournaments.*

Collegiate wrestling leagues face a challenging scheduling problem at their championship tournaments: What is a fair way to distribute the first-round byes among the individual wrestlers? The standard method sometimes leads to unsatisfactory brackets. We discuss the speaker's new bye-distribution method, which relies on a least-squares calculation to produce brackets that are fair to individual wrestlers and their teams. The method has been used successfully by the Eastern Intercollegiate Wrestling Association since 2006. (Received September 09, 2008)

1046-N1-702 **Robert Kantrowitz*** (rkantrow@hamilton.edu), 198 College Hill Road, Clinton, NY 13323, and **Michael M. Neumann**. *Hitting golf balls and tee balls as far as possible.* Preliminary report.

Golf balls and tee balls in flight may be modeled by projectile motion – the former launched from ground level, the latter from a height above ground level. In this talk, we will warm up with a reminder that, absent air resistance, the launch angle of 45 degrees maximizes the range of a golf ball. We then discuss the problem of finding the angles of launch that ensure maximal range for golf balls and tee balls when accounting for drag. Standard calculus, elementary differential equations, computer algebra systems, and an old, but sometimes forgotten function all play roles in the solution. (Received September 10, 2008)

1046-N1-1217 **Erich Kreutzer*** (erkreutzer@davidson.edu). *How fair are BCS ratings? Analysis of Colley Methods for Sports Ranking.*

The Bowl Championship Series (BCS) was formed in 1998 in an attempt to rank NCAA Division I college football teams. These rankings decide who plays in five prestigious end of the year bowl games. The rankings are composed of two parts human and one part computer rankings. Computer rankings come from an average of 6 different methods including a Colley method for ranking sports teams. When originally conceived this method consisted of a slight modification to the standard winning percentage formula. The Colley Matrix method stems from the standard Colley method, but includes a minor abstraction that results in a linear system that clearly incorporates the notion of strength of schedule. This talk will compare the two Colley methods by analyzing Division I NCAA college football data from the 2007 season. (Received September 15, 2008)

1046-N1-1236 **Roland Minton*** (minton@roanoke.edu), Department of Mathematics, 221 College Lane, Salem, VA 24153. *G.H. Hardy's Golfing Adventure.* Preliminary report.

A classic argument in golf is whether it is better to attempt risky shots or to play it safe. Surprisingly, this problem was examined by the great G.H. Hardy in a 1945 paper called "A Mathematical Theorem about Golf." He defines a golfer who is capable of excellent, normal and poor shots. An excellent shot lowers the golfer's score by one, while a poor shot raises the score by one. These occur with equal probability p. In this talk, Hardy's work is extended to compute mean scores and analyze competitions between golfers with different strategies. A risky golfer has a relatively high p-value and a cautious golfer has a relatively low p-value. Competitions include stroke play, match play, best ball team play and skins games. (Received September 15, 2008)

1046-N1-1477 **R. Drew Pasteur*** (rpasteur@wooster.edu). *Football Rankings Using Linear Algebra.* Preliminary report.

Most American football teams at the high school and collegiate levels play only a small number of games annually, compared to the number of teams in their leagues. In attempts to determine which teams are the best, or to accurately predict winners of future contests, many mathematical ranking methods have been developed. Most such ranking systems are based on complex statistical techniques; however, linear algebra can also be used sensibly, as we shall present in this talk. (Received September 15, 2008)

1046-N1-1548 **David J Hunter*** (dhunter@westmont.edu), Department of Mathematics, Westmont College, 955 La Paz Road, Santa Barbara, CA 93108. *Major League Baseball Meets Facebook: Modeling Trades Using Social Network Theory.*

A *social network* is a graph model for the relationships among the members of some population. The vertices, or *actors*, model the individual members, while the edges, or *ties*, indicate how actors are related. The history of transactions between major league baseball franchises is a good source of social network data: each franchise is an actor, and the ties are weighted according to the number of trades made between franchises. This talk will give a brief overview of some of the main concepts in social network theory at a level suitable for use in the undergraduate curriculum and undergraduate research projects. The franchise/trade example sheds some light on the business of baseball while illustrating how ideas from social network theory can bring interesting new applications into discrete mathematics and combinatorics courses. (Received September 16, 2008)

1046-N1-1582 **Howard Penn*** (hlp@usna.edu), Mathematics Department, 502 Holloway Rd, U.S. Naval Academy, Annapolis, MD 21402. *Jump Shot Mathematics.* Preliminary report.

Lisa Leslie takes a 15 foot jump shot, releasing the ball from a height of 10 feet and an angle of elevation of 60 degrees. What is the initial velocity in order for the ball to go through the basket? If we assume ballistic motion, this is an easy problem to solve. Later in the game she shoots from the same height and distance but at a 30 degree angle. It is well know that the initial velocity is the same. But the real question is: are these shots good? After all, a basketball is not a point mass, rather it is a sphere of diameter 9 inches. The basket has a diameter of 18 inches. How close does each of these shots come to the front rim? (Received September 16, 2008)

1046-N1-1731 **Eric W Kuennen*** (kuennene@uwosh.edu), Mathematics Department, University of Wisconsin Oshkosh, 800 Algoma Blvd., Oshkosh, WI 54901. *A Markov Chain Model of Baseball.*

This session will present a Markov Chain Model for Baseball that has been used as a student project in an undergraduate stochastic modeling course. We will introduce the idea of the Markov Chain, and discuss its applicability to the game of baseball. A model for baseball will be developed, and recent Major League Baseball statistics will be used to define transition probabilities. The applicability to the model will be illustrated by conducting both theoretical and computer-simulation analyses to investigate strategic questions, such as: in which situations is bunting most advantageous, and what success rate should a base runner have to make attempting a steal worth while. (Received September 16, 2008)

1046-N1-1773 **Andrew B Perry*** (perryand@yahoo.com), 90 Longfellow Drive, Longmeadow, MA 01106. *Traditional Introductory Statistics Restricted to Sports.*

Springfield College (MA) is a highly sports-oriented college and the faculty find that sports-related examples are received by the students with great enthusiasm . We in the mathematics department wanted to teach a statistics class which covers the traditional topics of an introductory one-semester Statistics course using data exclusively from the realm of sports, using a variety of different sports.

Unfortunately, there don't seem to be any textbooks on the market that accomplish these objectives. Jim Albert's "Teaching Statistics Using Baseball" is an excellent book but covers too limited a set of topics in statistics for our purposes and restricts itself to the sport of baseball only.

This presentation will describe the presenter's attempts to design the course described above using a variety of resources including Albert's book. It will include the results of the first live class test of this curriculum in the Fall 2008 semester. (Received September 16, 2008)

1046-N1-1882 **Michael Frantz*** (frantzm@ulv.edu), Chair, Math/Physics/C.S. Dept., University of La Verne, 1950 3rd Street, La Verne, CA 91750, and **Vanessa Alday**. *The Effects of Wind and Altitude on 400-m Sprint Performances with Various IAAF Track Geometries.*

The effects of wind and altitude on the performance of athletes in the 400-m sprint are modeled and analyzed for various IAAF track geometries, using a differential equations model developed by Quinn. The validity of our implementation of the model is established by comparing model output (produced via Maple software) with published results for the standard IAAF track. The model is then modified and extended to measure the effects of a constant wind velocity and altitude on equal quadrant, non-equal quadrant, and double bend IAAF tracks. The model indicates clear advantages to runners for specific track geometries in constant velocity wind conditions, although changes in track geometry play no appreciable role in altitude effects. A preferred wind direction is determined which predicts a slightly faster time than under windless conditions. Small but noticeable effects for different running lanes are also established, although many other factors also strongly influence lane choices. The mathematics involved is restricted to that found in standard precalculus, calculus, and differential equations courses, with the added bonus of the need to solve a cubic polynomial equation to approximate the degree of slowdown due solely to the curve of the track. (Received September 16, 2008)

1046-N1-1894 **Megan Elise Selbach-Allen*** (m095835@usna.edu), PO Box 15497, Annapolis, MD 21412, and **Sommer E. Gentry** and **Kevin L. McIlhany**. *How expert swing dancers exploit physics.* Preliminary report.

To determine whether and how expert swing dancers exploit physics to make their activity easier, this research focuses on a partnered spin. In this movement, two dancers connect hands and spin around a single vertical axis.

A theoretical model for the optimum spin pose for each couple was developed through analysis of inertia, torque and frictional forces. The differing size parameters for each couple are inputs to the model and the joint angles, θ, for the optimal pose are the outputs. The pose that maximizes the acceleration of the dancers is considered to be best:

$$\theta^* \quad = \quad \theta_{max} \frac{\tau(\theta)}{I(\theta)}$$

Where I(θ) is the moment of inertia of rotation around the vertical axis and $\tau(\theta)$ is the maximum torque the dancers could impose without overcoming the static friction between the floor and shoe.

To test the theoretical model, the motion of live dancers was captured using a motion capture system. Dance couples with varying degrees of skill were recruited for the study. The hypothesis was that expert dancers perform the spin in a pose closer to their optimal pose than novice dancers.
(Received September 16, 2008)

1046-N1-1931 **Eugene Belogay*** (ebelogay@fau.edu), Wilkes Honors College, FAU, 5353 Parkside Drive, Jupiter, FL 33458. *Walking or Running in the Rain: Myth Busted?* Preliminary report.

Is it better to walk or to run in the rain? This timeless question has even appeared on the popular Discovery Channel program *MythBusters*, with inconclusive results. Somewhat surprisingly, the answer is far from simple and the problem turns out to be more subtle than it may appear on the (wet) surface.

To paraphrase the famous title of John Harte's book *Consider a Spherical Cow*, we consider runners of various shapes — sticks, boxes, and even ellipsoids — and analyze their optimal rain exit strategy. Yes, the optimal strategy does depend on the shape of the runner and on the direction of the wind. The mathematical model is accessible to undergraduates and is aided by numerical computations in Excel spreadsheets. (Received September 16, 2008)

1046-N1-1991 **Michael A. Jones*** (maj@ams.org), Mathematical Reviews, 416 S. Fourth Street, Ann Arbor, MI 48104. *The Superbowl Box Pool.*

Each year approximately 45% of U.S. households watch the Superbowl and approximately $90 million is bet on the game. A common office pool, the Superbowl box pool, sells each square of a 10 × 10 grid for the same price. After all squares have been sold, the row and column headings are revealed to indicate the units' digits of the scores of the two teams. At the end of each quarter, a percentage of the collected money is returned to the person who bought the square that matches the teams' scores modulo 10. Although the pool is fair because each square is equally likely to be purchased for the same price and the expected value is zero, certain scores are clearly better, e.g., $(7, 0)$, than others, e.g., $(5, 8)$.

After years of running a Superbowl box pool at a neighbor's house, I thought about how to create odds for the different scores. I develop both 200-state and 100-state Markov chain models of Superbowl play to determine the likelihood of end-of-quarter scores. Touchdown, extra point, field goal, safety, and two-point conversion data from the 2008 NFL season are parameters for the model. Outcomes are compared with end-of-quarter data from both the 2008 NFL season and past Superbowls. I also discuss the assumptions and limitations of the model. (Received September 16, 2008)

1046-N1-2020 **Robin H Lock*** (rlock@stlawu.edu), Dept. of Math, CS & Stat, St. Lawrence University, Canton, NY 13617, and **Michael E Schuckers** and **Travis Atkinson**. *SiSSYS: A Senior Capstone Course Based on Statistics in Sports.*

We describe a Statistics in Sports Senior Year Seminar (SiSSYS) that was used as a capstone course for mathematics majors at St. Lawrence University with interests in both statistics and applications in sports. We discuss the motivation, structure and organization for the seminar as one option to fulfill our Senior Year Experience (SYE) requirement. The eight students in the seminar worked together with three faculty to explore various ways that statistical techniques and real data could be used to address practical questions arising in sports settings and then pursued individual projects tailored to each student's interests. We discuss some of results and findings from those studies with applications to baseball, football, basketball, hockey, golf and bowling. (Received September 16, 2008)

1046-N1-2062 **Elizabeth C Rogers*** (brogers@piedmont.edu), Piedmont College, Central Ave., Demorest, GA 30535. *Mathematics of the Olympics: From the Ancient Greeks to the Present.*

From the first Olympics held in 776 BC until today, mathematics has permeated every event in height, distance, weight, timing, scoring and multiple other facets of the games. This paper focuses mathematically on the sports that were included during 1100 years of the ancient games and compares them to the sports of the modern Olympic era. Many of the original sports such as the pentathlon continue in varied forms today. As man and mathematics have developed over the centuries, the Olympics have changed in a variety of ways, but some classic events such as the marathon still exist. Just as the ancient Greeks went to great lengths to insure fair competition, the modern games continue to struggle with the mathematics of "fairness." (Received September 17, 2008)

Mathlets for Teaching and Learning Mathematics

1046-O1-346 **Michael J. Caulfield*** (caulfiel001@gannon.edu), Department of Mathematics, Gannon University, 109 University Square, Erie, PA 16541. *A Flash Application Illustrating Napier's Bones.*

Napier's Bones, or Rods, represent one instance of lattice multiplication. In this presentation we discuss John Napier and his "Bones". His method is illustrated by means of a Flash application co-created by the speaker. Users may enter two factors up to six digits each and observe the step-by-step lattice multiplication process. The application is freely available through the Web. (Received August 27, 2008)

1046-O1-392 **Rick Klima*** (klimare@appstate.edu), Department of Mathematical Sciences, Appalachian State University, 342 Walker Hall, Boone, NC 28608. *A Maplet for Encoding, Decoding, and Correcting Errors in Golay Codes.* Preliminary report.

Golay codes are often relegated to a secondary role in mathematical coding theory behind more famous heavyweights such as Hamming and Reed-Solomon codes, despite their own utility and rich history of applications. For example, like Hamming codes, the binary G_{23} and ternary G_{11} Golay codes are among the few perfect codes that exist. Also, like Reed-Solomon codes, Golay codes were used in the Voyager 1 and 2 satellites during 1979-1981 when they transmitted color photographs of Jupiter and Saturn back to Earth. A current application of Golay codes is in the United States government standards for automatic link establishment in high frequency radio systems for forward error correction. In this presentation, I will demonstrate a Maplet that a student and I have written for encoding, decoding, and correcting errors in all types of Golay codes. We have found that this Maplet provides a means for teaching Golay codes to students with limited background knowledge and/or computer expertise. (Received August 29, 2008)

1046-O1-487 **Daniel Gries*** (dgries@hamilton.edu), Mathematics Department, Hamilton College, 198 College Hill Road, Clinton, NY 13323. *Fractal applets in Flash.*

I will present some interactive web-based mathematical applets, developed in Adobe Flash. The applets allow students to explore different types of fractals, including L-system fractals as well as complex iteration fractals such as the Mandelbrot set. The applets are designed to encourage exploration and include user interfaces which allow both mathematical and creative control of the ouput. (Received September 04, 2008)

1046-O1-913 **Paul Seeburger*** (pseeburger@monroecc.edu), Monroe Community College, 1000 E. Henrietta Rd., Rochester, NY 14623. *Making Calculus Come Alive with Dynamic Visualization Tools.* Preliminary report.

An introduction to a series of Java applets (and Excel demonstrations) developed by the presenter to help students visualize calculus. Some of the Java applets were created to support specific calculus texts, but a number of them can be found on the presenter's webpage. Illustrated concepts include tangent lines, rectilinear motion, Riemann sums, Euler's method, slope fields, Taylor polynomials, washer and shell methods, volumes with a common cross-section, 3D graphs of functions of two variables, limits of functions of two variables, contour plots, the method of Lagrange multipliers, visualizing a double integral, etc. The presenter is also involved in an NSF funded project that focuses on helping students visualize multivariable calculus. (Received September 12, 2008)

1046-O1-1153 **Robert J. Decker*** (rdecker@hartford.edu), University of Hartford, Mathematics Dept, 200 Bloomfield Ave., West Hartford, CT 06117. *Mathlets for Continuous and Discrete Dynamical Systems.* Preliminary report.

Interactive math applets (mathlets) allow the user to experience mathematical relationships in ways that are impossible with any other approach. The presenter has created a number of mathlets targeted at many levels, including precalculus, calculus, differential equations and dynamical systems. This talk will focus on mathlets that can be used in a typical first course in differential equations, and in a follow-up course on dynamical systems (continuous and discrete). Mathlets that target the following areas will be demonstrated: bifurcations of autonomous equations in one and two dimensions, periodic solutions and the Poincare map, relationships between discrete iterated maps and differential equations via the Poincare map and via numerical approximations, bifurcations and Lyapunov exponents for iterated maps, and strange attractors for both discrete and continuous systems. Besides being dynamic (immediate response to changes in initial conditions or parameters), many of the applets use side-by-side multiple views of the system being studied (such as phase plot with time plots) to drive home conceptual understanding. The mathlets can also be used for demonstration, in conjunction with labs/projects, or for independent undergraduate research. (Received September 14, 2008)

1046-O1-1261 **Kenneth G Monks*** (monks@scranton.edu), Department of Mathematics, University of Scranton, Scranton, PA 18510, and **Nathan C Carter** (ncarter@bentley.edu), 175 Forest St, Waltham, MA 02452. *Toy Proofs.* Preliminary report.

What is the difference between a formal proof and a computer game? We discuss the use of formal games as a pedagogical tool to introduce students to the concept of proof. We also demonstrate software designed for this purpose by the authors under the Lurch Project (NSF Grant #0736644). (Received September 15, 2008)

1046-O1-1377 **Elisha Peterson*** (triathematician@gmail.com). *Java Mathlets 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 applets featured include (i) a generic function plotter with interactive parameter sliders, (ii) a dynamically-adjustable iterated curve generator, and (iii) an applet highlighting the role of the gradient vector in pursuit and evasion algorithms. In each case, Blaise automatically handles interactivity and animation. The process of constructing these mathlets using Netbeans may also be discussed. (Received September 16, 2008)

1046-O1-1819 **Kady Schneiter*** (kady.schneiter@usu.edu), Department of Mathematics and Statistics, 3900 Old Main Hill, Logan, UT 84322. *Statlets: Statistics Applets and Activities.*

Statistics concepts abound in state secondary-level mathematics core curricula and are emphasized in the content standards of the National Council of Teachers of Mathematics. Inspired by the National Library of Virtual Manipulatives, we have created a collection of interactive applets for teaching statistics (statlets). These are simple and narrowly focused and have been specifically designed for use in secondary or introductory college level mathematics and statistics courses. We have emphasized simplicity, clarity, and ease-of-use in their design in order to best meet the needs of beginning statistics students and have created a number of inquiry-based guided activities to facilitate their incorporation into classroom teaching. We will introduce these tools, describe student response to them, and discuss plans for future development. (Received September 16, 2008)

1046-O1-1876 **Eugene Belogay*** (ebelogay@fau.edu), Wilkes Honors College, FAU, 5353 Parkside Drive, Jupiter, FL 33458. *How Fit is Your Model? Interactive Data Fitting in Excel.* Preliminary report.

Experimental data rarely fit theoretical models perfectly. Constants in the laws of nature do not miraculously appear on *Wikipedia* —- they are often estimated by finding the unknown parameters in the law that best fit the experimental data.

Most computational tools available to science students today can compute a best fit to a set of measurements so quickly and easily that few students know or care what is really going on "inside the box." This is a pity, as scientists often gain valuable insight into a problem only by playing out various what-if scenarios. An easy way to improve one's "gut feeling" is to observe how the model curve reacts to changes in the model parameters. Of course, the calculus of partial derivatives can provide analytical answers, but they rarely have the immediate impact of watching a curve wiggle on the computer screen with every twitch of the mouse.

Our interactive data-fitting mathlet (or is it mathsheet?) was inspired by the excellent applets from The Shodor Foundation (www.shodor.org) and is implemented as a single Excel spreadsheet without any VBA code, so instructors can easily customize it without any special programming knowledge. Although commercial software by Microsoft, the cross-platform Excel is abundant on campus. (Received September 16, 2008)

Operations Research in the Undergraduate Classroom

1046-P1-21 **William C. Bauldry*** (BauldryWC@AppState.edu), Dept of Mathematical Sciences, Appalachian State University, 121 Bodenheimer Drive, Boone, NC 28608. *Data Envelopment Analysis in Operations Research.*

We will discuss presenting the Data Envelopment Analysis technique as an undergraduate Operations Research topic. A class project used in a combined undergraduate/graduate course will be shown. A student project and further directions for student work will be offered. (Received May 29, 2008)

1046-P1-63 **Morteza Shafii-Mousavi*** (mshafii@iusb.edu), Mathematical Sciences, PO Box 7111, South Bend, IN 46634-7111. *Mathematical Methods of Operations Research.*

The paper describes operations research modeling approach used in Mathematical Modeling courses offered for diverse majors. Courses encourage appreciation of math as students see an immediate use for it in solving real world problems. The coverage includes modeling techniques, linear and nonlinear optimization, sensitivity analysis, convexity analysis, networks, dynamic programming, stochastic processes, queuing theory, Markov chains, and post optimality analysis. In each course, real-world problems are modeled using math elements, formulated for computer OR software, programmed into spreadsheets, solved by the Excel Solver, and implemented post optimality and sensitivity analysis. Students practice phases of an OR study by solving problems. For each problem, students define the problem, formulate a math model, develop a spreadsheet model, use a software and/or EXCEL to derive solutions, and write a report on their findings and recommendations. Evaluation include: exams, homework, individual and team projects. The department uses the written reports of these team and individual projects for program assessments. I will present the course syllabi, innovative instructional strategies, assessment methods, individual and team projects, technology, and reports completed by students. (Received July 22, 2008)

1046-P1-401 **Ronald M. Brzenk*** (brzenkr@hartwick.edu), Hartwick College, Department of Mathematics, Oneonta, NY 13820. *Using Interactive Pedagogies to teach Operations Research.* Preliminary report.

This paper will describe a variety of interactive teaching techniques used in courses in Operations Research and Mathematical Modeling. Examples of class projects and cooperative group assignments will also be presented. The role of these projects in assessing student learning will also be discussed. (Received August 31, 2008)

1046-P1-1225 **William P Fox*** (wpfox@nps.edu), Department of Defense Analysis, Naval Postgraduate School, Monterey, CA 93943. *The "Artist Guild" Strike: An Example of Game Theory.*

In our 3rd course in mathematical modeling, we teach modeling for decision making. The course covers some linear programming, risk analysis, decisions under risk, and game theory. Our coverage of game theory is fairly complete covering theory and applications of zero-sum games, non-zero sum games, Nash arbitration, and "n"-player games. This past year, we modeled the "artist guild" strike as a 2-person non-zero sum game. We used the von Neumann and Morgenstern method of lottery to obtain the pay-off matrix and Nash Arbitration to show an acceptable result. We will also present our graphical approach to Nash Arbitration in this example that we teach our students. (Received September 15, 2008)

1046-P1-1562 **Mark Evans**, **Lilinoe Harbottle**, **Ken Shun** and **Alan Krinik*** (ackrinik@csupomona.edu), Alan Krinik, Department of Mathematics and Statistics, 3801 W. Temple Avenue, Pomona, CA 91768. *Recursive formulae for Steady State Distribution of a Certain Class of Markov Process.*

An apparently new method of recursively determining the steady state distribution of a certain type of Markov process (having a finite or countable state space) is presented. Our approach may be viewed as a development of the iterative manner in which steady state probabilities of a general birth-death process are usually developed in standard operation research or stochastic process texts. Our technique is particularly useful for finding the steady state distribution of challenging Markov processes having a countable number of states. For suitable Markov processes, our method offers students and practitioners an alternative approach to the traditional generating function approach for finding steady state distributions of non birth-death, infinite state space Markov processes. As an example, we discuss the steady state distributions of bulk arrival queueing systems. A simple relationship between the transient probability functions of a Markov process and its dual transient probability functions is the key connection needed to establish our method. (Received September 16, 2008)

Performing Mathematics

1046-Q1-849 **Leon Harkleroad***, 102 Fenderson Hill Rd, Wilton, ME 04294. *Möbius and Grassmann on Musical Tuning Systems.*

In the mid-1800s Möbius devised a tuning of the chromatic scale. He described this tuning, which belongs to the family of so-called just intonations, and its underlying principles in a letter to Grassmann. A return letter by Grassmann modified Möbius' system to obtain a couple of others. This talk will present their work and its relation to other historical tuning methods. (Received September 12, 2008)

1046-Q1-864 **John M. Harris*** (john.harris@furman.edu), Department of Mathematics, Furman University, Greenville, SC 29613. *Magic from a Distance.*

"Coming up next — you perform an amazing feat of magic right from your own living room!" Magic specials on television frequently include effects in which viewers participate from home. Other examples of distance magic can be found in great number on the internet and in email inboxes. Not surprisingly, mathematical interpretations of these effects often illuminate the working principles. In this talk we will investigate several of these effects, and we will see how they can be incorporated into classroom experiences. (Received September 12, 2008)

1046-Q1-885 **Tim Chartier*** (tichartier@davidson.edu), Department of Mathematics, Davidson College, Box 6908, Davidson, NC. *Using mime to see the remainder.*

Marcel Marceau often exclaimed (off-stage, of course) that the art of mime could make the invisible visible. Tim Chartier, who trained with Marceau, will discuss his use of mime to introduce mathematical ideas. Further, he will present a sketch that is used in the college classroom and in performance from elementary school to collegiate levels to demonstrate ideas of a remainder in division and prime numbers. (Received September 12, 2008)

1046-Q1-1515 **Karl Schaffer*** (schafferkarl@fhda.edu), P.O. Box 8055, Santa Cruz, CA 95061. *Dance and Mathematics: A Survey.* Preliminary report.

Despite a recent wave of work connecting mathematics to the arts, less has been done with respect to the art of dance. We will examine possible explanations for this, but will also briefly look at a variety of connections that have been explored, for example, links to polyhedral geometry, intricate baroque dance notation systems, rhythms in percussive dance forms, choreographer Merce Cunningham's use of randomness, math/dance integrations designed for the classroom, and end with a survey of recent or upcoming performances (including those of the speaker). We will also look at how mathematical problems can arise during or inspire the choreographic process, and will outline possible future directions. (Received September 15, 2008)

1046-Q1-1627 **sarah-marie belcastro*** (smbelcas@toroidalsnark.net). *Laban's Choreutics and Polyhedra.*

Rudolf Laban's *The Language of Movement: A Guidebook to Choreutics* (posthumously published in 1966) contains mathematical images and textual references, and in particular there are many diagrams depicting annotated polyhedra. Analyses of the mathematics in Laban's work are few and have only been done from a dance perspective rather than from a mathematical perspective. We will begin this talk with a review of the references to mathematics in *The Language of Movement* and the existing scholarship thereon. We will then focus on Laban's use of polyhedral diagrams: What dance ideas did he convey through these diagrams? Did he use mathematical properties of polyhedra in his work, or only their aesthetic qualities? What (well known) mathematics is implicitly present but not explicitly stated in his text and diagrams? (Received September 16, 2008)

1046-Q1-2009 **Stephen H. Harnish*** (harnishs@bluffton.edu), Bluffton University, 1 University Drive, Bluffton, OH 45817. *Juggling sequences with number theory–"A tale of two kingdoms".*

Certain infinite sequences have the property that an initial sum equals a middle sum. For example, the simple sequence $1, 2, 3, 4, \ldots$ has an initial sum of $1 + 2 + 3 + 4 + 5 + 6$ equaling 21 which is also the value of the middle sum $10 + 11$. We will explore whether or how this property holds for the sequences of even and odd numbers, the Fibonacci sequence, as well as the sequence: $1, 7, 19, \ldots, (3i(i + 1) + 1), \ldots$ Surprisingly enough, the answers to these questions lead to a number-theoretic resolution for an "anthropo-mathematical" tale of the cultural clash between two kingdoms respectively valuing monistic and dualistic sequential periodic juggling. (Received September 16, 2008)

1046-Q1-2034 **Colm Mulcahy*** (colm@spelman.edu) and **Tim Chartier** (tichartier@davidson.edu).
Six Fibs and Videotape.

Mathematicians do not generally lie or encourage their students to do so, at least not in the cause of education. Mathemagicians, however, are another story. Who could doubt the veracity of such claims as, "This deck has been fairly shuffled," "Your card was picked completely at random," or "I can read your mind, and now I will prove it." In this presentation we'll explore some fun and surprising applications of a well-known sequence from the realm of discrete mathematics, with the help of a willing and curious mime. (Received September 16, 2008)

Productive Roles for Math Faculty in the Professional Development of K-12 Teachers

1046-R1-44 **Connie H. Yarema*** (connie.yarema@acu.edu), ACU Box 28012, Abilene, TX 79699-8012, and **Cheryl D. Schwiethale** (cds04a@acu.edu), ACU Box 28012, Abilene, TX 79699-8012. *Japanese Lesson Study: A Process to Build and Foster Communities of Practice Dedicated to the Professional Development of Mathematics Teachers.*

This presentation highlights the process of lesson study implemented by university mathematics faculty as a means of building communities of practice among educators in K-16 schools. Lesson study, a Japanese professional development model, requires that "practitioner" teachers become researchers who collaboratively spend an extensive period of time setting goals, consulting higher education faculty, planning a unit and research lesson, observing the teaching of the research lesson, gathering data pertaining to student learning, and revising the research lesson to deepen student learning of a difficult concept (Stigler & Hiebert 1999, Lewis 2002, Takahashi & Yoshida 2004). Outcomes from lesson study consist of teachers' growth of mathematical knowledge, pedagogical knowledge, and knowledge of students' learning of mathematics as illustrated by past and current lesson studies conducted in Abilene, Texas, funded through the Texas Teacher Quality Grants Program. The presentation focuses on a local middle school whereby teachers and principal indicated the desire to form a community of practice with mathematics and education university faculty whose role is to implement lesson study on site at their school supported by online technological tools such as blogs and web-conferencing. (Received July 01, 2008)

1046-R1-181 **Kirsten Fleming*** (flemingk@nku.eduMCKRXN), 504 Johns Hill Road, Northern Kentucky University, Highland Heights, KY 41099. *The Kentucky Center for Mathematics.*

The Kentucky Center for Mathematics (KCM) is a statewide center housed at Northern Kentucky University. The goals of the KCM are to enhance the teaching and learning of mathematics in the Commonwealth of Kentucky. A strategy for accomplishing these goals is to provide teachers with research-based professional development programs. To this end, the KCM coordinates professional development programs in diagnostic intervention for K-3 teachers and in mathematics coaching for K-12 teachers. The structure of these programs will be discussed. An extensive evaluation of the effects of these programs is being undertaken: results of this evaluation will be used to discuss the positive impact of these programs on teachers and students. The steps that are being taken to ensure the sustainability of these programs will also be addressed. (Received August 13, 2008)

1046-R1-456 **Elizabeth A. Burroughs*** (burrough@math.montana.edu), Department of Mathematical Sciences, PO Box 172400, Bozeman, MT 59717-2400. *Using Lesson Study to Enhance Content Knowledge and Use of Inquiry in Middle School Classrooms.*

This session will describe a professional development project that uses lesson study to (1) increase middle school mathematics teachers' content knowledge; (2) to promote their use of inquiry-based pedagogy in classrooms; and (3) to strengthen school-based mathematics learning communities. Twelve teachers in two different towns formed two mathematics lesson study teams, each team spanning grades 5–8. Each team conducted a six-week lesson study cycle with guidance from university faculty. The teams focused on algebraic content knowledge and using inquiry-based pedagogy. The session will report results from the first lesson study cycle, as well as present a synopsis of ongoing plans to incorporate pre-service middle school mathematics teachers into the project. (Received September 03, 2008)

1046-R1-486 **Linda Braddy*** (lbraddy@ecok.edu), East Central University, 1100 East 14th Street, Ada, OK 74820. *"If only I had known then what I know now. . . " : A look back at six years of professional development programs.*

The Mathematics Department at East Central University (ECU) in southeastern Oklahoma has provided eleven grant-funded content-focused professional development programs for K-12 teachers of mathematics over the past six years. Approximately 350 public school teachers have participated in the programs. The programs have consistently produced large gains in the content-knowledge of participants as measured by pre- and post-assessments in addition to dramatic changes in classroom pedagogy and increases in self-confidence in the classroom (self-reported). The program curriculum and instruction has always been a joint effort between ECU mathematics and mathematics education faculty and public school teachers identified as "master teachers". All but the first three programs have been collaborative efforts between ECU and public school districts. This presentation will include a look back at the programs and lessons learned by the program directors, as well as a look at current efforts and plans for future programs. (Received September 04, 2008)

1046-R1-550 **Davida Fischman*** (fischman@csusb.edu), Department of Mathematics, California State University, San Bernardino, 5500 University Pkwy, San Bernardino, CA 92407. *Supporting Mathematics Teachers to Increase Retention Through Professional Development: Overview, Models and Research.*

Can professional development make a difference in teacher retention, content knowledge, and self-efficacy in teaching mathematics? This session will address the challenge of supporting new mathematics teachers and mathematics teachers in hard-to-staff schools as viewed through (1) an overview of a statewide California project consisting of 10 sites, and (2) the lens of one of the sites, the Inland Counties Mathematics Project. The site-specific description will look at one model including the content, activities, goals, results and challenges of that site. The overview will outline models of support offered across the 10 project sites, the research design and initial results. (Received September 07, 2008)

1046-R1-589 **Philip B. Yasskin*** (yasskin@math.tamu.edu), Department of Mathematics, Texas A&M University, 3368 TAMU, College Station, TX 77843-3368. *Brazos Valley Math Teachers' Circle: Formation and Activities.* Preliminary report.

Faculty from Texas A&M University and teachers from surrounding Middle and High Schools have recently formed the Brazos Valley Math Teachers' Circle (see http://www.math.tamu.edu/outreach/BVMTC/) as part of the National Math Teachers' Circle Network (see http://mathteacherscircle.org/). Our mission is to promote a culture of enjoyment of mathematics problem solving activities among middle and high school teachers with the expectation that they will take the activities and their enthusiasm back to their classrooms. This talk will discuss the organization and some of the activities, many of which are taken from the National MTC Network, the A&M Summer Educational Enrichment in Math program (see http://www.math.tamu.edu/outreach/SEE-Math/) and the NSF GK-12 program at A&M run by the Partnership for Environmental Education and Rural Health (see http://peer.tamu.edu/). (Received September 08, 2008)

1046-R1-621 **Juli D'Ann Ratheal*** (ratheal_j@utpb.edu), 4901 E. University Blvd., MESA Office 4132, Odessa, TX 79762. *Creating Active Learning Environments with Improved Student/Teacher Relationships and State Assessement Scores.*

Data will be presented which supports the conjecture that increasing the level of student engagement will improve conceptual understanding and retention of learning objectives. Data was collected over a three year period measuring the effects of specific instructional interventions for two diverse student population groups, middle school mathematics students and college algebra students. Information will include: 1) funding sources, 2) structure and design of content workshops, 3) topics and resources included in pedagogical training, 4) student surveys, and 5) external evaluator reports. The professional development activities have resulted in the following: 1) a significant increase in students' conceptual understand, 2) a deeper conceptual understanding among teachers, 3) increased state assessment scores,4) improved classroom management skills, 5) created learner-centered environments, 6) improved teacher/student relationships, and 7) initiated changes in instruction from lecture-based to active-learner based. (Received September 09, 2008)

1046-R1-754 **Julie A. Belock*** (jbelock@salemstate.edu), Salem State College, 352 Lafayette St., Salem, MA 01970. *Mathematics Content Knowledge and Classroom Practice in Middle School.* Preliminary report.

At Salem State College, our M.A.T. in Middle School Mathematics is targeted to teachers originally licensed as elementary generalists but who now teach mathematics in grades five through eight. The program began as a grant-funded professional development partnership with three local school districts. Our assessment process has included pre- and post-testing in the mathematics content courses and follow-up observations (by liaisons in the districts) of the teachers implementing lessons based on what they had studied in our courses. In addition, we have surveyed program participants as to their own level of comfort with the mathematics and how they have used it in their classrooms. I will briefly outline our program and present our findings. (Received September 10, 2008)

1046-R1-812 **Betsy Darken*** (betsy-darken@utc.edu), Mathematics Department # 6956, University of Tennessee at Chattanooga, 615 McCallie Ave., Chattanooga, TN 37403. *Mathematicians vs. Future K-8 Teachers: Is Real Communication Possible? Is Deep Learning Achievable?*

Effective specialized mathematics content courses for future teachers are critically important for improving K-8 mathematics education in the United States. However, there are major problems confronting mathematicians who dare to teach such courses. I will discuss these problems using information obtained from mathematics education research as well as personal experience. In particular I will examine counterproductive assumptions made by both teachers and students, problems related to students' weak backgrounds, gaping gaps in communication, the difficulties inherent in breaking the vicious cycle of mediocre education, issues connected to teaching students how to think, quandaries posed by students' poor attitudes, and ways to deal with the shock of discovering the apparent absence of mathematical understanding among many of your students. Finally I will present research data on a success story, including years' worth of pretest-posttest data that reveal how much students can learn in a single mathematics content course, including gains in factual and procedural knowledge, conceptual understanding, and problem-solving ability. (Received September 11, 2008)

1046-R1-869 **Cathy S Liebars*** (liebars@tcnj.edu), The College of New Jersey, Department of Mathematics and Statistics, 2000 Pennington Road, Ewing, NJ 19047. *Sustained professional development in urban and suburban middle schools: is it effective?*

We will describe a US DOE-funded project with one urban district and a few surrounding suburban districts in which Mathematics department college faculty teach graduate math content courses for middle school teachers after school on site in the districts. Courses meet once a week for 2 1/2 hours throughout the semester and teachers can elect to take the courses for graduate credit. College faculty use middle school curricula as a basis for exploring the math content in the course. Data was collected on student test scores, teacher surveys, and classroom observations (done by undergraduate preservice teachers engaged in independent research) and compared to a control group. Differences were found in several areas of classroom practice between the treatment and control groups. (Received September 12, 2008)

1046-R1-950 **Evan Fuller*** (edfuller@ucsd.edu), 9266 Regents Rd, Apt B, La Jolla, CA 92037, and **Osvaldo Soto**, **Guershon Harel** and **Alfred Manaster**. *In-Service Teachers' Proof Schemes in Transition.*

The goal of this research is to examine cognitive, social, and instructional aspects in the transition between proof schemes: from the external conviction and empirical proof schemes to deductive proof schemes, focusing, in particular, on the transition from Result Pattern Generalization to Process Pattern Generalization. Of particular focus is the instructor's way of implementing DNR in his attempt to facilitate this transition. Preliminary findings indicate that Empirical proof schemes are resistant to change. However, there is evidence to believe that a focus on causality over a long period of time can prove effective. The teaching practices that have been used to instantiate this focus on causality are also reported here. (Received September 12, 2008)

1046-R1-1003 **Heather R Mathison*** (swinney@math.montana.edu), Montana State University, 2-214 Wilson Hall, Bozeman, MT 59715. *Mathematical Inquiry in the Elementary Classroom after Teacher Participation in Professional Development.*

Twenty four middle school and upper elementary school teachers participated in a year long professional development program whose goals included improving teacher understanding of mathematical inquiry and supporting the teachers as they implemented inquiry in their classrooms. Discussion will focus on rural, fifth grade teachers who had not previously been exposed to the notion of inquiry and on the changes they made in their mathematics classrooms over the course of the school year. As a result of their participation in the program, these teachers began collaborating and creating their own lessons that were more supportive of inquiry than the lessons provided by the textbook. They modified their curriculum to cut extraneous topics and to enable students to spend more time on topics that were covered. They convinced their school board to buy new reform based math texts for the following year and began aiding teachers in lower grades with the use of inquiry. (Received September 13, 2008)

1046-R1-1295 **Katherine J. Mawhinney*** (mawhinneykj@appstate.edu), 330 Walker Hall, 121 Bodenheimer Dr., Boone, NC 28608. *Contributing to the Professional Development of K-12 Mathematics Teachers.*

There are many ways in which mathematicians may support their K-12 colleagues in mathematics education. The North Carolina Teaching Excellence and Mathematics II, Partners, and Teacher Algebra Network projects offer three very effective, yet different examples of teacher professional development that include efforts of mathematicians. Topics discussed in this session will include details of these projects' structure, but will focus on the roles STEM faculty played in these efforts. Some of the responsibilities of STEM faculty include advising project direction, creating and delivering professional development, and co-authoring professional development with K-12 teachers. (Received September 15, 2008)

1046-R1-1310 **Jennifer J. Kosiak*** (kosiak.jenn@uwlax.edu), Mathematics Department, 1020 Cowley Hall, 1725 State Street, La Crosse, WI 54601, and **Jon Hasenbank** (hasenban.jon@uwlax.edu), Mathematics Department, 1020 Cowley Hall, 1725 State Street, La Crosse, WI 54601. *Teaching for understanding through a professional development partnership.*

How do we teach mathematics for understanding? This question served as the basis for a professional development partnership between math faculty and 8-12 educators. This session will emphasize the development and structure of this year-long partnership that was designed to help middle- and high-school mathematics teachers improve the depth of students' knowledge of algebraic procedures. Productive impacts on teacher knowledge and pedagogical practices will be linked to improvements in student understanding. A digital classroom observation instrument designed to evaluate teachers' instructional emphasis on procedural understanding will also be discussed. (Received September 15, 2008)

1046-R1-1476 **Kathryn Ernie*** (Kathryn.T.Ernie@uwrf.edu), 206E North Hall, River Falls, WI 54022, and **Erick B Hofacker** (Erick.B.Hofacker@uwrf.edu), 214C North Hall, River Falls, WI 54022. *Connecting Higher Education Mathematics Faculty to K-12 Mathematics Teachers.*

The authors will describe three different programs they are apart of and assist in coordinating on their campus that links higher education mathematics faculty together with K-12 mathematics teachers in their area.

The first connection is the "Math Model Academy". The Academy is a weekend retreat which brings together teachers from all grade levels to discuss, present, and showcase issues affecting mathematics education. Past issues have involved using different forms of technology to teach, algebra across the grade levels, and preparation of mathematics students for life at college.

Our second connection is a set of ESEA summer courses taught by higher education faculty to K-12 math teachers. One of the authors will discuss his two-year involvement in the program through teaching a course on effective ways to use technology to teach mathematics.

Our third connection is a SoTL project, Infusing K-12 Exemplars in Content Courses for Teachers, which invites higher education faculty to collaborate with K-12 math teachers as consultants. The K-12 teachers provide content teaching knowledge exemplars for adaptation, discussion, and use in mathematics content courses geared toward pre-service mathematics teachers. (Received September 15, 2008)

1046-R1-1559 **Maria G Fung*** (mfung@worcester.edu), Mathematics Department, 486 Chandler Street, Worcester State College, Worcester, MA 01602, and **Tevian Dray**, **Dave Damcke**, **Dianne Hart** and **Dianne Riverstone**. *Math Faculty as Partners in Team Teaching a Non-Euclidean Geometry Course for K-12 Teachers.*

We will discuss how the Oregon Mathematics Leadership Institute (OMLI) enabled a team of five instructors, including a master teacher and four mathematics faculty, to design and implement a course on non-Euclidean geometry for K-12 teachers. We will focus on the intense structure of the course, which was delivered in 15 2-hour sessions. We will also discuss the content of the course, which included units on both taxicab and spherical geometry. Finally, we will emphasize the pedagogy of the course, which included hands-on cooperative learning that was carefully orchestrated to ensure everyone's participation, as well as skilled facilitation that was aimed at eliciting productive mathematics discourse, and thus at improving understanding of mathematical concepts. (Received September 16, 2008)

1046-R1-1730 **Terran D Felter*** (tfelter@csub.edu), CSUB Dept of Mathematics, 14 SCI, 9001 Stockdale Hwy, Bakersfield, CA 93311, and **Axelle P Faughn** (afaughn@email.wcu.edu), Western Carolina University, Department of Mathematics & Computer Science, Stillwell 426, Cullowhee, NC 28723. *The Role of Mathematics Faculty in Supporting Teachers to Increase Retention: A Constructivist Model.*

The CMP Supporting Teachers to Increase Retention project goals are to address dimensions of teacher retention by providing a comprehensive induction/support program for teachers of mathematics to increase retention, content knowledge and leadership and to conduct research that adds to the knowledge base on mathematics teacher retention. The Cal Poly SLO/CSU Bakersfield CMP STIR site project's participants are from three high-need districts and take Masters of Arts in Mathematics courses, each including a lab component to familiarize the participants with investigation-based teaching and learning strategies; intensive use of technology to support learning empowers the participants with knowledge of using technology in their own classrooms. Data collected indicate the courses help create bonds between participants and should prove helpful in increasing teacher leadership. Collaboration between math faculty at CSUB and the K-12 community provides opportunities to network during week-long professional development institutes, addressing key pedagogical issues in response to the participants' expressed need. Other opportunities for building collegiality and increasing participants' content knowledge arise during participation in conferences and leadership development retreats. (Received September 16, 2008)

1046-R1-1798 **Marie P. Sheckels*** (msheckel@umw.edu), Department of Mathematics, 1301 College Ave., Fredericksburg, VA 22401, and **Debra Hydorn** (dhydorn@umw.edu), Department of Mathematics, 1301 College Ave., Fredericksburg, VA 22401. *A Program of Courses to Prepare Highly Qualified Teachers of Middle School Mathematics.*

Faculty at the University of Mary Washington participated in a multi-institutional state-wide grant to create and teach courses to provide in-service teachers with the mathematical background and resources for teaching middle school mathematics. Each of the four courses was taught jointly by a mathematics professor and a master teacher, who was an experienced, certified middle school or high school mathematics teacher. The courses were designed to improve the teachers' mathematical understanding and model recommended pedagogical strategies. This presentation will provide information about the series of courses that make up the program and the overarching grant. The presenters will also relate their experiences teaching the courses, report on assessing the teachers' learning, and offer suggestions on how to improve future course offerings. (Received September 16, 2008)

1046-R1-1984 **Randall E. Groth*** (regroth@salisbury.edu), 1101 Camden Ave., Dept. of Education Specialities, Salisbury, MD 21801, and **Jennifer A. Bergner** (jabergner@salisbury.edu), 1101 Camden Ave., Dept. of Mathematics and Computer Science, Salisbury, MD 21801. *A Lesson Study Approach to Developing Productive Dialogue between University Mathematics Faculty and High School Teachers.* Preliminary report.

Lesson study is an approach to professional development that involves several interrelated phases. Groups of teachers collaborate to design a lesson. They then implement it and discuss its effectiveness with an eye toward continuing to polish the lesson in the future. The presenters will describe the dynamics of a lesson study project funded by a mathematics partnership grant from the State of Delaware. The project is unique in that university mathematics faculty, in collaboration with lead teachers at the high school level, were involved in helping frame and address critical issues in designing lessons to be taught to high school students. After the lessons were taught, university mathematics faculty participated in conversations with teachers about what went well in the lessons and what needed improvement. Over the course of the project, lessons were designed that dealt with various topics, including the Pythagorean Theorem, polynomial multiplication, and systems of equations. To demonstrate the effectiveness of the approach, the presentation will describe how the lesson study project allowed university mathematics faculty to help high school teachers refine their approach to teaching polynomial multiplication and factorization using algebra tiles. (Received September 16, 2008)

1046-R1-2064 **Brian J Lindaman*** (linda086@umn.edu), 830 Larpenteur Ave. Unit 1, Saint Paul, MN 55113, and **Terry Wyberg** (wyber001@umn.edu), Curriculum and Instruction, Room 125 Peik Hall, 159 Pillsbury Dr S E, Minneapolis, MN 55455. *Middle School Teachers Connecting Content and Student Thinking.*

Minnesota recently passed legislation requiring Algebra I for all eighth grade students. The State Department of Education initiated funding to train current middle school teachers in preparation for this change. Partners from the University of MN, Hamline University, and Normandale College created the professional development module to be used in the Twin Cities area. The project will train approximately 500 teachers from over 30 districts in the area during 2008-09. The topics covered in the module are equality, patterns, ratio and proportion, solving equations, and modeling. While improving content knowledge among the teachers has been one goal, much of the training has focused on preparing each teacher to research their own students' understanding of algebra. Each teacher investigated student understanding via a baseline questionnaire, interviews, and a follow-up. Results were shared among the teachers in professional learning communities (PLCs) within each building. This talk will describe the collaborative process by which the algebra module was created by university faculty and K-12 teachers, and describe the research support for the teacher-led classroom investigations. Some components of the training, including the role of the PLCs, will be discussed as well. (Received September 17, 2008)

1046-R1-2076 **Matthew J Haines*** (haines@augsburg.edu), 2211 Riverside Ave, Augsburg College CB 28, Mathematics Department, Minneapolis, MN 55454, and **Tracy Bibelnieks** and **Linda Stevens**. *An Update of a Professional Development Project focused on Preparing Students for Algebra.* Preliminary report.

Reports such as the National Mathematics Advisory Panel Final Report and state governments legislating that all students be ready to take algebra by eighth grade are putting increased pressure on teachers at middle and elementary grade levels to address preparing all students for algebra. Many professional development programs are providing additional training for teachers. This talk presents the work of one of those programs in Minnesota, the role that mathematics faculty play in the professional development, and the benefits their involvement has created for the mathematics department. (Received September 17, 2008)

Promoting Deep Learning for Mathematics Majors through Experiential Learning, Writing, and Reflection

1046-S1-161 **Jeffrey W. Clark*** (clarkj@elon.edu), Campus Box 2320, Elon University, Elon, NC. *Writing in Undergraduate Mathematics: From Special Topics Course to an Integrated Approach.*

Writing in Undergraduate Mathematics: From Special Topics Course to an Integrated Approach

Writing skills are viewed as crucial for our mathematics majors in our department; the students truly achieve mastery over the material when they are able to articulate it.

At Elon we long ago set a goal for using writing throughout our major. We now have articulated specific writing goals for the courses in our sequence, from short projects in our calculus classes through proofs of moderate length in our mid-level classes to longer papers in our research seminar; this talk will review the steps that we took in doing so. (Received August 13, 2008)

1046-S1-482 **Despina Prapavessi*** (dprapave@dvc.edu), **Karen Edwards** and **C. Samuel Needham**. *Calculus Field Trips.*

This talk will present the Calculus Field Trips Project under way at Diablo Valley College (DVC) which infuses examples of everyday applications of calculus into the standard calculus curriculum guided by various science and engineering professionals. Funded by NSF-DUE (CCLI- 0633289), faculty are organizing 14 class field trips every semester to local engineering firms, state and federal agencies and research labs in the area. Typically, a class of about 25 students and their instructor visit a company for a one hour presentation from a scientist or engineer on how Calculus is relevant in their work. Alternatively, speakers give presentations at the DVC campus or deliver content in a web conference format. Following the field trip students complete a collaborative project with classmates based on the scientific application they learned about. These activities help students make the connection between the classroom and workplaces in their local community, thus developing a focus and purpose for their academic studies. Moreover, partnerships are built between the faculty and their scientific or engineering counterparts in industry. (Received September 04, 2008)

1046-S1-528 **Katarzyna Potocka*** (kpotocka@ramapo.edu), Ramapo College of New Jersey, School of TAS, 505 Ramapo Valley Road, Mahwah, NJ 07430. *Implementing SENCER ideals into an introductory statistics course.* Preliminary report.

The author describes her experiences of developing and implementing group projects that promote deep and long-lasting understanding of the most crucial concepts in an introductory statistics course through experiential learning. The projects implement SENCER ideals into the course (Science Education for New Civic Engagements and Responsibilities). The goal of SENCER is to improve science and mathematics education by connecting learning to critical civic questions. In 2007 the author applied for and received a SENCER–NSF grant for implementing such ideals to her course. This paper is a report of progress based on the last three semesters of her work. The projects are conducted by students outside of a classroom, which promotes active learning and independent thinking. Students use modern statistical methods to investigate a topic of their own choosing that is a civic issue and they explain why their findings may improve the local or the global society. Investigating a topic of their own choosing increases student interest in the course. The projects consist of a sequence of assignments that include real-life data collection, computations, interpretations, a report to a real-life agency related to the civic issue being investigated, a reflection paper, and an evaluation form. (Received September 06, 2008)

1046-S1-692 **Ryan J Zerr*** (ryan.zerr@und.edu), University of North Dakota Mathematics Dept, Witmer Hall Room 313, 101 Cornell Street Stop 8376, Grand Forks, ND 58202, and **Jessica M Zerr** (jessica.zerr@und.edu), University of North Dakota English Dept, Merrifield Hall Room 110, 276 Centennial Drive Stop 7209, Grand Forks, ND 58202. *Using Peer Reviews in Proof-Based Mathematics Courses.*

We report on the use of peer reviews as an integral component in various proof-based mathematics courses. This system, which was inspired by the way peer reviews are used to teach English composition, involved students writing proofs, critiquing the proofs of their peers, and then responding to the feedback they received. In this way a critical reading component can be added to an existing course by requiring students to carefully read and analyze proofs which are not known *a priori* to be correct.

In addition to a description of this peer review process's implementation, we present data that was collected from student work produced over the course of a semester. These data provide evidence for the effectiveness of the process in helping students to be more reflective about their proof writing, and also suggest that students would benefit from the inclusion of more opportunities to critique incorrect proofs. (Received September 10, 2008)

1046-S1-1147 **Joyati Debnath*** (JDebnath@winona.edu), 301 Gildemeister Hall, Mathematics and Statistics, Winona State University, Winona, MN 55987. *Deepening Mathematical Concepts through Presentations and Writing Research Findings.*

This presentation will discuss how a new course on Mathematical Thinking for the mathematics majors was established. In this course, students are encouraged and constantly challenged to read and present their understanding to the class. Students were either given or allowed to choose an advanced topic of their interest to do research. The class time is used for conversation and serious mathematical discussion. Students report their findings and attempt to integrate their thoughts in a way that they have never done before. Classroom environment allowed students to reflect on their presentations. Students are also required to write a research article. (Received September 14, 2008)

1046-S1-1173 **Sarah L Mabrouk*** (smabrouk@frc.mass.edu), Framingham State College, Mathematics Department, 100 State Street, Framingham, MA 01702-2499. *Why Should I Take Statistics? - Let's "Talk".*

Guiding students to an understanding of how to apply and to interpret statistics is challenging. Helping students to gain an understanding of and an appreciation for the application of Statistics in various disciplines facilitates greater understanding as well as enables students to value their study of Statistics. At Framingham State College, MATH 117 Introduction to Statistics is a required/recommended course for major concentrations offered by eleven departments. Since fall 2003, students enrolled in the Honors section have explored the application of

Statistics in these disciplines. This exploration has grown to include interviews of faculty teaching in these disciplines, presentation of these interviews online, and online discussion of the use of Statistics in these disciplines among the students in the dual enrollment section. Through online discussions, students gain a deeper understanding of how they may use Statistics in the future as well as learn how their instructors may use Statistics. So, as students "talk" online, they reflect on the importance and usefulness of the aspects Statistics that they study. In this presentation, I will discuss the evolution of this course component, the students' reaction to its use, and the students' online interaction. (Received September 15, 2008)

1046-S1-1420 **Thomas W Milligan*** (tmilligan1@ucok.edu), Dr. Thomas Milligan, Department of Mathematics and Statistics, Edmond, OK 73034-5209. *Learning Through Generalization: Using First Semester Calculus Concepts to Teach Multivariable Calculus.* Preliminary report.

One of the most useful skills that a beginning mathematics student needs to learn is how to generalize, or take a known concept and use it in a more abstract or more general setting. For example, taking the definition of an open interval and translating it to open disks in two dimensions. The study of both differential and integral calculus on functions of two or more variables is an ideal setting to introduce students to the skills needed to generalize ideas on there own, while also reinforcing those concepts learned in the first semester calculus course. Starting at the definition of multivariable functions and immediately followed by the limit definition, one can introduce to students how to generalize the one-variable definitions to use them to define concepts in two or more variables. After modelling how to do this with the first couple concepts, one can begin to ask students how to generalize the concepts on their own. Different possible methods are discussed, and some student successes and problems are addresses. (Received September 15, 2008)

1046-S1-1488 **Edwin P Herman*** (eherman@uwsp.edu), Department of Mathematical Sciences, University of Wisconsin, Stevens Point, Stevens Point, WI 54481. *Using Discussion Boards to Enhance Understanding in Mathematics Courses.* Preliminary report.

Ideally, online discussion boards allow students to organize their ideas and more easily reference those of other students. This can lead to increased enthusiasm and a stronger sense of ownership of the material. Unfortunately, poorly designed boards can also be a disaster, especially for those unfamiliar with them. Because of this, many instructors shy away from this useful technology.

It is not necessary to be an expert to add an online component to a course, nor does it require major retooling. A modest investment of time can yield positive results by encouraging students to mentor each other or collectively tackle larger problems.

I have used discussion boards for three different courses (both major and non-major). The boards were used in conjunction with assigned homework problems. Grading schemes varied by course: one course required weekly posts; one gave extra credit; and one gave no grade credit. As you might imagine, participation rates and student feedback also varied.

In my presentation I will discuss what I have learned about what to do and what not to do when incorporating discussion boards into a math course and offer useful references for those interested in trying them out for themselves. (Received September 15, 2008)

1046-S1-1524 **Benjamin J Galluzzo*** (bgalluzz@math.uiowa.edu), Department of Mathematics, MacLean Hall, University of Iowa, Iowa City, IA 52242. *Midwest Math-In: 24 Hours of Math.*

COMAP's Mathematical Contest in Modeling successfully encourages teamwork, creativity and written exposition — all in the name of mathematics. However, one (logistically necessary) element that many students remark is lacking from this competition is adequate and timely feedback — both from the micro perspective "What do the judges really think of my team's paper?" to the macro "How did other teams answer this question?" This past year, I led a project involving faculty from colleges and universities in and around Iowa to develop a response to our students' concerns. The result is the Midwest Mathematical Modeling Competition, an on-site, 24-hour contest that calls for student teams to communicate their mathematical solution to a real world problem in both oral and written formats. In this talk we will discuss the contest, its development, and share the results of a survey of student participants. (Received September 16, 2008)

1046-S1-1578 **Doug M Fletcher*** (douglas.fletcher@usma.edu), Department of Mathematical Sciences, West Point, NY 10996, and **Gary Kramlich**, Fort Bragg, NC 28310. *How to Stop a British Ship: Projectile Motion, the Revolutionary War, and West Point.*

West Point's storied history began during the Revolutionary War when it was established to help prevent the British from using the Hudson River. The Americans constructed a great chain across the river and set up numerous artillery batteries on land. In theory, the great chain would stop British ships in the river so the artillery batteries could destroy them. Although the chain was never tested, the layout of the artillery batteries went through several changes in order to provide better support. The lesson itself requires two periods and incorporates the history of West Point with hands-on experience to motivate the concepts of projectile motions. During the first period, students get the opportunity to experience the challenges of firing from one of the batteries using a potato gun as an artillery piece. For the second period, the instructor presents different scenarios using historical information about the artillery pieces and their location at West Point. The students will determine whether or not they could have stopped a British ship using projectile motion equations. (Received September 16, 2008)

1046-S1-1719 **Rachelle M Ankney*** (ankney@gmail.com), 1728 W Estes Ave, Apt G, Chicago, IL 60626. *Does Service-Learning Make Sense When I Hate Math?*

Several North Park math education students took on a research project with Dr.Ankney in her general education math classes to see if service learning helps non-math-major learners feel more of a connection with the material in their math classes. This largely qualitative study followed up on a more quantitative experiment Dr.A previously conducted. We present our preliminary findings, including where our graduating math education students plan to use our discoveries and the challenges of combining mathematics and service-learning meaningfully in a lower-level course. (Received September 16, 2008)

1046-S1-1747 **Brian P Kelly*** (bkelly@bryant.edu), 1150 Douglas Pike, Smithfield, RI 02917. *Escalating Writing Assignments in Calculus 1.*

We have developed a series of web-based discovery activities that include discussion questions to foster a deeper understanding of calculus. We implemented this because our freshman calculus students have adequate computational skills, but will struggle to explain their thought processes. The assignments escalate in the sense that as the semester progresses, the students are asked more open-ended questions requiring longer responses. This presentation will explore the performance of the students through this progression as well as the pedagogical concerns incorporated into the design of the assignments. (Received September 16, 2008)

1046-S1-1900 **Feryal Alayont*** (alayontf@gvsu.edu), Grand Valley State University, Mathematics Department, 1 Campus Drive, Allendale, MI 49401. *Inquiry-based learning in a discrete mathematics with graph theory course.* Preliminary report.

The topics in discrete mathematics courses provide a wealth of problems that students can investigate and make conjectures about without being introduced to the topic in the classsroom or through reading. This presentation will focus on an inquiry-based style discrete mathematics course for math majors with a significant graph theory component. Students are assigned presentation problems related to the material for the next class and are asked to create their own approaches to solving these problems. Through student presentations and group activities these appoaches are discussed in class and generalized if possible. This course format enables students to form a base of knowledge on which the in-class instruction can build. Sample assignments as well as student response to the course will be discussed. (Received September 16, 2008)

1046-S1-1905 **Erica L Johnson*** (ejohnson@sjfc.edu), 3690 East Avenue, Rochester, NY 14607. *Developing Future Secondary Teachers' Mathematics Knowledge (for Teaching) with Student Presentations.* Preliminary report.

In alignment with recommendations from the MET report (CBMS), the course Advanced Perspectives on School Mathematics was designed to help students to connect their undergraduate mathematics experience to the high school mathematics curriculum and to deepen their understanding of the mathematics they will teach. Students take this course the semester prior to student teaching. To foster the transition from learner to teacher and to help prepare them for student teaching, students present the material from selected sections of the textbook, "Mathematics for High School Teachers, an Advanced Perspective" by Usiskin et al. Class presentations include questions and class discussion and are supplemented with a writing component. Students use online discussion boards to post class notes for each section and field questions from their peers about the material. This talk will describe how this assignment was developed and has evolved, including student reflections on the experience, lessons learned, and enhanced features. (Received September 16, 2008)

1046-S1-1972 **Alex Meadows*** (ammeadows@smcm.edu), Department of Mathematics, SMCM, St. Mary's City, MD 20686-3001. *Thoughts on a modified moore method course in undergraduate analysis.* Preliminary report.

We discuss a recent undergraduate analysis course that included various models of inquiry-based learning. We give details on the different methods, results of student feedback on them, and outcomes in terms of attitudes and confidence based on written reflections. (Received September 16, 2008)

1046-S1-1986 **Mairead Greene*** (mairead.greene@rockhurst.edu). *The Role of an Inquiry-Based Classroom in Promoting Deep Learning for Mathematics Majors: A Case Study.*

Last semester, the students in my undergraduate Number Theory course experienced the power that comes with discovering knowledge in an inquiry-based classroom. They learned to take a general question, experiment with some specific situations to gain understanding, form a conjecture from this experimentation, perform further experimentation to test and refine this conjecture and, finally, prove their conjecture. They engaged in this process both inside and outside of the classroom and recorded their work in an ongoing Number Theory Journal. They completed weekly reflections on their experience in the class and how this was impacting their learning. This presentation will also include discussion of the final report that the students prepared, the classroom environment that allowed this approach to succeed and the systematic study of the reflections that took place after the course ended. (Received September 16, 2008)

1046-S1-2045 **Jose H. Giraldo*** (jose.giraldo@tamucc.edu), Mathematics and Statistics Dept., Texas A&M University-Corpus Christi, 6300 Ocean Dr, Corpus Christi, TX 78412. *Discussion and Revisiting of Calculus Concepts to Gain Understanding of Main Concepts.* Preliminary report.

Several years ago I decided to change the approach to teach calculus concepts as well as the sequence of topics to help the students in their learning and enduring understanding of the basic concepts from calculus I. This change led to reconsider the study of calculus by emphasizing the understanding of the discrete to better understand the reasoning in the continuous. Due to this approach a main discussion in this course is about limits of sequences leading to limits of functions. Under this approach there is a constant revisiting of terms and concepts that otherwise are relegated to isolated discussions in calculus. I will share the effect of understanding sequences to the general understanding of concepts such as integration, sided derivatives, and numerical approximations in general. A main component of this approach is the students participation in class and group discussions, writing of solution to problems, and in general verbal justification of any results. (Received September 16, 2008)

1046-S1-2070 **Jialing Dai*** (jdai@pacific.edu), 3601 Pacific Ave, Stockton, CA 95211. *Semi Inquiry-Based Learning in Undergraduate Real Analysis.* Preliminary report.

In this talk, I will share my experience in teaching undergraduate real analysis I at the University of the Pacific. Real Analysis I is the first semester real analysis. It is one of the most difficult math courses required for math majors. To help students overcome their fear and build up confidence, I decided to try something slightly different: Have students work in groups and present their work in class. In addition, students are also required to carefully write up problems presented. There are four components in the write-up: (a) Identify the hypothesis and the conclusion, whenever it is appropriate. (b) State any definitions/theorems/results are used in the solution. (c) Describe the thinking process of how they approach and solve the problem, and finally (d) clearly write up the solution. At the beginning of the course, this seems difficult and intimidating to some students, but gradually students start gaining confidence and become eager to present problems and lead the discussion. The learning outcomes seem quite positive although I have no statistical data to support it. Students claimed they have learned a lot and they really understood the mathematics. I will show some sample students' work in the talk. (Received September 17, 2008)

Quantitative Literacy Across the Curriculum

1046-T1-570 **Stuart Boersma*** (boersmas@cwu.edu), Department of Mathematics, 400 E University Way, Ellensburg, WA 98926, and **Teri Willard** (willardt@cwu.edu), Department of Mathematics, 400 E University Way, Ellensburg, WA 98926. *Medical Accuracy: Content for a Quantitative Literacy Course.*

An extended study of accuracy in medical screening is presented as a useful application to increase students' quantitative reasoning skills. Two detailed examples are presented. The first explores the frequency of obtaining false positive results from a medical screening tool while the second examines the issue of referral bias and its effect on the apparent sensitivity and specificity of the screening tool. Results from student assessments indicate that the activity increases one's ability to define terms such as "false positive" and "false negative" and increases one's ability to read and compute with information obtained from a two-way table. Teacher assessment results indicate that the activity is challenging and could be used in existing high school or college classrooms. Additionally, links to a student activity, instructor notes, and Excel calculation tool are provided. (Received September 08, 2008)

1046-T1-1299 **Stuart Boersma*** (boersmas@cwu.edu), Department of Mathematics, 400 E University Way, Ellensburg, WA 98926, and **Caren L Diefenderfer** (CDiefenderfer@hollins.edu) and **Bernard L Madison** (bmadison@uark.edu). *Using Media Article to Drive a QL Course.* Preliminary report.

Materials developed by Bernard L. Madison and Shannon Dingman are now being implemented at three universities across the country. These materials allow an instructor to design an introductory QL course around media articles with the overarching goal of helping students develop the power and habit of mind to search out quantitative information, critique it, reflect upon it, and apply it in their public, personal, and professional lives. The authors will discuss how this course is implemented on their respective campuses. Special attention will be given to student and course assessment practices. (Received September 15, 2008)

1046-T1-1464 **D. Scott Dillery*** (dillerys@lindsey.edu), 210 Lindsey Wilson Street, Columbia, KY 42728. *Toward a Numerate Culture: A Quantitative Literacy Project.* Preliminary report.

A multi-disciplinary team from Lindsey Wilson College was awarded a small grant in the summer of 2008 to promote numeracy (quantitative literacy) on its campus. The grant funding is being used to coordinate and educate existing academic support services and to pay small stipends to faculty who create numeracy activities for their courses. The activities will be documented and made available to other faculty. Faculty who are not in disciplines usually associated with quantitative information have been especially encouraged to participate. This talk will summarize the college's efforts and milestones to date. (Received September 15, 2008)

1046-T1-1565 **Kelly E Matthews*** (k.matthews1@uq.edu.au), **Merrilyn Goos** and **Peter Adams**. *Building the mathematical and computational skills of science students: what we are doing, what students think, and how it is working.*

The University of Queensland in Brisbane, Australia is a large, research-intensive institution. A recent review of the Bachelor of Science (BSc) highlighted a deficit in the quantitative abilities of science students, which was supported by feedback from final year undergraduate and honours level science students. Thus, several strategies were developed to better instil science graduates with mathematical, statistical and computational skills in the BSc. This talk will focus on the development, implementation and initial evaluation of a new, first year course that embeds mathematics and computer programming across a range of real world scientific problems. As a "gateway" course into the BSc, the aim is for students to better understand the interdisciplinary nature of science, how mathematics underpins various scientific disciplines, and the role of computational modelling in scientific research. This will, in turn, allow for upper level courses to build on and incorporate quantitative skills within the context of specific disciplines. Initial evaluation results will be presented, along with some of the challenges of developing this course and the issues associated with embedding quantitative reasoning across all levels of the BSc. (Received September 16, 2008)

1046-T1-1599 **Cinnamon Hillyard*** (chillyard@uwb.edu), Campus Box 358511, 18115 Campus Way NE, Bothell, WA 98011, and **Nicole Hoover**. *Making Quantitative Reasoning Central to a PreCalculus Course.*

With the onset of our lower division program, we recently designed a new precalculus course with quantitative reasoning (QR) as the primary learning goal. We will discuss how we integrated QR into a course already packed with mathematical content to prepare students for calculus. We will highlight what worked particularly well, including asking students how to critically reflect, reason, discuss, and write about mathematics. We will also address our challenges and hopes for future versions of this course that put QR into the forefront. This talk adds to the ongoing discussion of the place of a calculus curriculum in a QR program and how to provide authentic QR experiences within a math course. (Received September 16, 2008)

1046-T1-1744 **Kira Hamman*** (khh11@psu.edu), Penn State Mont Alto, 1 Campus Drive, Mont Alto, PA 17237. *Mathematics and Democracy.*

Mathematics and Democracy is a general education quantitative literacy course which ties together a variety of QL topics by relating them to the democratic process. Course topics include voting methods, apportionment, voting power, and fair division, and the course has included lectures by a historian, a political scientist, and a judge. Students in the course are encouraged to become more politically aware and to apply the mathematics they learn to a topic that particularly interests them. This talk will cover course development, curriculum, and lessons learned. (Received September 16, 2008)

1046-T1-2057 **Gary T Franchy*** (gary.franchy@davenport.edu), 27650 Dequindre Road, Warren, MI 48092. *QL from a Service Division Perspective.*

The Mathematics department at Davenport University serves strictly as a service division in support of the school's programs in business, technology, and health professions. As such, a conscious effort has been undertaken to use the context of the university's programs to motivate the content within the developmental and introductory math courses. An additional benefit of the collaboration between Davenport's discipline and math faculty has been the identification and bridging of several disconnects in how quantitative topics are presented. Examples in the areas of accounting/finance, nursing, and social science will be discussed in detail. (Received September 16, 2008)

1046-T1-2069 **Kimberly M Vincent*** (vincent.kimberly@gmail.com), WSU, Dept of Mathematics, PO Box 643113, Pullman, WA 99164-3113. *Incorporating Quantitative Literacy into the Research Writing Classroom.* Preliminary report.

Frequently students must be able to accurately analyze data and make logical inferences, whether conducting original research or discussing other's research in order to represent reality in their research. Yet composition teachers often neglect to provide students with instruction on how to interpret and make inferences about quantitative information. Our students often use statistics found through library and internet searches to support their written arguments and claims, yet they do not always know how to avoid skewing reality, nor do they understand how questioning the statistic or other evidence is one of their responsibilities as an ethical researcher. A common assumption is that numbers and statistics must be valid. Thus, teachers do try to relay the importance of questioning the bias of statistical information, just as they encourage students to critique all sources. However, composition teachers, while skilled in helping students evaluate rhetoric, frequently do not have the resources to help students make reasonable inferences from statistics, nor to judge their validity. Ways instructors addressed QL in their composition writing classes will be shared. (Received September 17, 2008)

Research on the Teaching and Learning of Undergraduate Mathematics

1046-U1-227 **Theresa A Laurent*** (tlaurent@stlcop.edu), St Louis College of Pharmacy, 4588 Parkview Place, St Louis, MO 63110-1088. *An Analysis of College Mathematics Placement Policies for Students with High School Calculus Experience.*

The number of students taking calculus in high school has been increasing dramatically since 1982 but commercially available placement tests still do not include calculus topics. It is unclear if current placement policies for students with high school calculus experience are accurately placing students. This research investigates placement policies for this population by surveying math departments and administering a calculus placement exam to freshmen with high school calculus experience. Departments were surveyed to determine characteristics of their calculus sequence, current placement policies and satisfaction levels with their policies. A causal-comparative design was used to compare groups based on institution enrollment, institution selectivity, course characteristics and policy characteristics. Freshmen with calculus experience completed a placement exam to determine their calculus achievement. A causal-comparative design was used to compare groups of students based on their high school experience (i.e.: earned credit by AP Calculus exam score, earned dual-enrollment credit, or did not earn credit). The results of the survey and calculus placement exam will be discussed along with implications and recommendations for departmental placement policies. (Received August 20, 2008)

1046-U1-504 **Bonnie Gold*** (bgold@monmouth.edu), Mathematics Department, Monmouth University, 400 Cedar Avenue, West Long Branch, NJ 07764-1898. *Addressing student difficulties with negating mathematical statements and translating statements from English to symbolic form.* Preliminary report.

Psychologists have studied difficulties people have with reasoning skills generally, and in particular with negating statements, but have not specifically studied these issues in mathematics majors. I have been teaching our Introduction to Mathematical Reasoning, which is primarily taken by freshman mathematics majors, since 2005. Generally the course is successful in introducing students to proof. However, it has been less successful in getting students to correctly state the negation of an "if...then..." statement, and to translate statements from standard mathematical phrasing to symbolic form (to enable them to use truth tables or formal reasoning rules to check their deductions). In this study, based on Harel's DNR-based Instruction Framework, I used different methods for each issue in my two sections this semester (some methods coming from work in psychology, some from work by other mathematicians) to see whether any method improved student learning of these skills. I will discuss this study and some initial analysis of the data I collect this semester. (Received September 13, 2008)

1046-U1-531 **Jana R Talley*** (jtalley@ou.edu), 355 48th Ave. NW #4, Norman, OK 73072. *Instructor Responses to Prior Knowledge Errors Within a Calculus I Course.* Preliminary report.

This study investigates the responses to prior knowledge errors that Calculus I instructors make when assessing students. Prior knowledge is operationalized as any skill or understanding that a student requires to successfully navigate through a Calculus I course. A two part qualitative study consisting of student exams and instructor interviews was employed to examine how instructors approach prior knowledge mistakes while evaluating students. Instructors of a summer Calculus I course were interviewed and asked to elaborate on exam grading decisions. Analysis of these interviews were used to develop additional questions for Calculus I instructors of various research and teaching backgrounds. All interviews were analyzed to illuminate common trends and unique assessment strategies among instructors. (Received September 06, 2008)

1046-U1-564 **Dale J Winter*** (amanita@andrew.cmu.edu), Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213, and **Matthew E DeLong** (mtdelong@taylor.edu), Department of Mathematics, Taylor University, Upland, IN 46989. *Students' Mental Models and Success on a Calculus Word Problem.*

Word problems present significant difficulties to many students. Educational researchers have suggested that creation of an accurate mental model constitutes an important step in solving a word problem. A "mental model" might be described as a mental representation of the physical situation described by the word problem. This talk will report the results of three investigations of the relationships between students' mental models and their success at solving a calculus word problem. We will report the results of a survey (n=317) to uncover the demographic factors contributing to students' ability to create an accurate mental model. We will report the results of a correlational study (n=70) in which the flexibility and accuracy of students' mental models was related to their level of mathematical expertise. Finally, we will describe the results of a correlational study (n=143) that related the accuracy of students' mental models to their ability to set up an equation, take derivatives and solve the word problem. Results suggest that while mental models lacking serious conceptual flaws are important, students' success in solving a calculus word problem is more strongly predicted by proficiency with mathematical operations rather than accuracy of their mental models. (Received September 08, 2008)

1046-U1-1289 **Aaron D. Weinberg*** (aweinberg@ithaca.edu), Department of Mathematics, Ithaca College, 953 Danby Rd, Ithaca, NY 14850, and **Thomas J. Pfaff**. *Designing and Assessing Hands-On Statistics Activities: The Central Limit Theorem and Hypothesis Testing.* Preliminary report.

Many demonstrations and activities have been suggested for helping students understand complex statistical concepts. However, few of these have been evaluated for their impact on student learning.

We designed a collection of hands-on activities to help students explore the central limit theorem, confidence intervals and hypothesis testing (specifically the 1- and 2-sample proportion tests and the 1-sample t-test). We administered written pre- and post-tests to assess students' understanding and a written survey at the end of the course to assess students' opinions of the activities. Students responded positively to the activities and reported that the activities helped them understand the concepts. However, the results from the tests were mixed. This underscores the importance of formally assessing the effectiveness of pedagogical materials.

In this talk, we will describe the design of our activities, the assessments, and the results from our pilot study. We will then discuss how we are using a constructivist theory of learning to redesign the activities, the way we implement them, and our assessment tools. (Received September 15, 2008)

1046-U1-1390 **Vilma Mesa*** (vmesa@umich.edu), 610 East University, 1360F SEB, Ann Arbor, MI 48109-1259, and **Peichin Chang** (peichin@umich.edu), 610 East University, 1300F SEB, Ann Arbor, MI 48109-1259. *Dialogical Engagement in Two Interactive Mathematics Lessons.*

This study examined the language used by two instructors teaching two mathematics classes for undergraduate students that exhibited high student participation. Upon a more detailed analysis of the dialogical engagement regarding the use of two voices, heteroglossia and monoglossia, it was possible to see that the two classes differed substantially, with the discourse of one instructor exhibiting more instances in which multiple voices were included, acknowledged, and invited and the discourse of the other instructor exhibiting more instances in which alternatives were not sought nor accepted. The analysis revealed the multiple functions that each voice carried, supporting current views regarding the multi-vocality of interactions. We discuss implications for research and for faculty development regarding managing classroom interaction. (Received September 15, 2008)

1046-U1-1414 **Jessica M Deshler*** (deshler@math.wvu.edu), Department of Mathematics, 320 Armstrong Hall, PO Box 6310, Morgantown, WV 26506-6310. *A Two Semester Study of Interactions In Multi-Section Undergraduate Mathematics Classes.* Preliminary report.

This is both a qualitative and a quantitative study of multi-section undergraduate mathematics courses at a research university in the southwest United States. The researcher employed systematic classroom observation over a period of two semesters to determine teaching practices that predict student success. Classes were categorized qualitatively after each semester based on the overall amount of interactions observed during the class. Detailed data was also gathered during the study, once by the researcher, once by course coordinators, also by systematic classroom observation using a trial observation protocol. Instructor and student behaviors were monitored, as well as several different types of instructor-student interactions. Logistic regression analysis was used to measure the influence of student background data, course taken, instructor, observed teaching practices and interactions on student performance and the significance of the researcher's qualitative classifications. Classes categorized as 'highly' or 'minimally' interactive were statistically significant predictors of student performance for at least one semester, as were student-initiated logistic interactions and both instructor- and student-initiated interactions requiring an academic explanation. (Received September 15, 2008)

1046-U1-1443 **Stacey A. Bowling*** (stacey.bowling@asu.edu), 4607 E La Costa Dr, Chandler, AZ 85249. *Using a Model-Eliciting Activity to Teach Exponential Growth: An Investigation of Student Conceptions and Affect.*

Exponential functions form an important component of calculus courses and they provide useful models for understanding real-world phenomena, such as population growth, compound interest and radioactive decay. Yet research has shown that students who have successfully completed calculus hold impoverished notions of multiplicative growth and decay. To facilitate students' conceptual understanding, research suggests that model-eliciting activities may provide opportunities for promoting students' local conceptual development in mathematics. Drawing on this research, a model-eliciting activity was designed to promote the emergence of exponential growth by creating intellectual need for an exponential growth model, in a context designed to evoke a positive affective response. Analysis of data from a group modeling activity and post-interviews with three students reveals students' developing understanding of exponential growth and students' affective response to the activity. Early data supports that this activity shows promise, with additional refinement, for promoting development of ideas of exponential growth and for evoking positive affective response in students. (Received September 15, 2008)

1046-U1-1471 **Kevin C. Moore*** (kmzipsgolf@gmail.com), 1522 South River Dr., Tempe, AZ 85281. *An Investigation of Students' Problem Solving Abilities: Where's the quantity?*

This study investigated undergraduate students' ability to make meaning of and solve word problems. Specifically, it focused on how students conceived and reasoned about quantities of a contextual situation that covary and how these conceptions influenced their abilities to formalize relationships between quantities. The results revealed difficulties in the students' ability to conceive of and reason about quantities in a problem context. Many of these difficulties stemmed from the mental image they developed of the quantities and their relationships. The students' inattentiveness to the relationships between quantities often inhibited their progress toward a stated solution. In contrast, when the students were successful in obtaining a stated goal, they appeared to have a dynamic mental model of the problem situation; they formed images of the measurements of quantities to be related and were able to imagine how the values of these quantities changed in tandem. These results provide insights about the complexities that students encounter in attempting to solve word problems. It also highlights the importance of students' development of cognitive models of quantities and their relationships before attempting to reason about and algebraically formalize these relationships. (Received September 15, 2008)

1046-U1-1716 **Jason Howard Martin*** (jmartin@ou.edu), Department of Mathematics, University of Oklahoma, 601 Elm Ave. PHSC 423, Norman, OK 73019. *Expert vs. Novice Understanding of Convergence of Taylor Series.* Preliminary report.

Taylor series is a topic briefly covered in most university calculus sequences. In many cases it constitutes only one or two sections of a calculus textbook. With this limited exposure, what do calculus students really understand about the convergence of Taylor series? Do they think of Taylor series convergence as a sequence of converging polynomials? Do they think of convergence as a remainder going to zero? Do they think the Taylor series for sine really "equals" sine? Or is it merely a good estimation for sine? If our goal is to turn novices into experts, then we should also consider how experts comprehend Taylor series. Therefore, this presentation will report qualitative research incorporating questionnaires and interviews to help shed light on expert and novice understanding of the convergence of Taylor series. Using insights from previous research on the notion of limit, we will compare and contrast the mental imagery of experts and novices and the situations in which they employ their different images. (Received September 16, 2008)

1046-U1-1760 **Eric W Kuennen*** (kuennene@uwosh.edu), Mathematics Department, University of Wisconsin Oshkosh, 800 Algoma Blvd, Oshkosh, WI 54901, **Jennifer E Szydlik** (szydlik@uwosh.edu), Mathematics Department, University of Wisconsin Oshkosh, 800 Algoma Blvd., Oshkosh, WI 54901, and **Carol E Seaman** (ceseaman@uncg.edu), Mathematics and Statistics, University of North Carolina Greensboro, Greensboro, NC 27412. *Measuring Mathematical Sophistication.*

The goal of this project is to develop and validate an instrument to measure a new construct for making sense of what it means to know mathematics. In previous research, we observed that a lack of mathematical sophistication denied the preservice teachers in our study access to both conceptual and procedural knowledge of elementary mathematics. This led us to propose a framework for describing the values and ways of knowing of the mathematical community. Now we have designed a paper-and-pencil, multiple-choice instrument to measure mathematical sophistication, and we assessed both the validity and reliability of the instrument with a large sample of undergraduate mathematics students. In this presentation, we will discuss the theoretical framework of mathematical sophistication and the development, validity and reliability of our instrument. We will share and discuss sample test items from our instrument, and elaborate on how we plan to use the instrument to study the relationship between our construct of mathematical sophistication and the retention of both conceptual and procedural knowledge of elementary mathematics. (Received September 16, 2008)

1046-U1-1771 **Stacy A Brown*** (stacy_brown@pitzer.edu), 3326 Duke Avenue, Claremont, CA 91711. *A Multiage Examination of Students' Approaches to Mathematical Induction Tasks.*

Research on undergraduates' understandings of proof by mathematical induction (PMI) has shown that undergraduates experience difficulty with this proof technique (e.g., Dubinsky, 1989; Movshovitz-Hadar, 1993). Harel and Sowder (1998) and others (Brown, 2003), however, have questioned the extent to which these difficulties are due to traditional instructional approaches that tend to hastily introduce the definition of mathematical induction and do not facilitate the development of PMI as a means to solve a class of problems. In an effort to distinguish between those difficulties that are didactical in nature (that is, due to instructional choices) and those that are epistemological (that is, whose origin is the concept itself), this paper will examine findings from two teaching experiments. The first involved undergraduate mathematics and science majors. The second is ongoing and involves advanced 6th grade students. The purpose of the paper is to explore similarities and differences in the students' approaches to PMI-appropriate tasks and then to use the multi-age comparison to evaluate potential epistemological obstacles to PMI. (Received September 16, 2008)

1046-U1-1871 **Paul C Dawkins*** (rdawkins@uta.edu), 3908 Rustic Forest Trl., Arlington, TX 76016. *Bringing a Formative Approach to Definitions in Undergraduate Real Analysis: Theoretical Considerations and Preliminary Results.* Preliminary report.

"Despite being the dominant mode of teaching advanced mathematics for many decades, the [Definition-Theorem-Proof] format has been widely maligned by mathematicians and mathematics educators alike" (Weber, 2004, p. 116). This form of instruction poorly reflects how proof is developed historically (Alibert & Thomas, 1991) which, according to constructivist theory, parallels how individual learners attain these concepts (Piaget & Garcia, 1989). However, seeking viable, research-based alternatives for instruction in undergraduate Real Analysis presents a special challenge. As a part of a larger study directed toward this goal, we will discuss preliminary findings from a case study on one Real Analysis course that emphasized the development and motivation of definitions more than their final form. A significant amount of class time focused on students developing their own understanding of the central ideas that the formal definitions are meant to capture, before providing a formal definition. A linguistic, conceptual, and cognitive characterization of the instruction and the evidence of its efficacy regarding comprehension, recall, and affective factors will be described via analysis of results from intensive instructor and student interviews and classroom observations. (Received September 16, 2008)

1046-U1-1897 **Jason K. Belnap*** (belnap@mathed.byu.edu), 183 TMCB, Provo, UT 84602. *Ascertaining the Professional Development Needs of Graduate Mathematics Teaching Assistants.* Preliminary report.

Graduate mathematics teaching assistants (GMTAs) are heavily involved in undergraduate education, greatly impacting the quality of mathematics instruction. Understanding this, most departments provide formal professional development (PD) for their GMTAs. While the duration and makeup of PD varies greatly, many evidence planning and complexity, aimed at providing GMTAs with ongoing support or mentoring. As departments and researchers have given more attention to GMTA PD, they have asked researchers poignant questions regarding PD, such as: how much should be provided? what specific content is important to cover? and what are the most effective activities in preparing new GMTAs?

The answers to these questions are crucial to the success and effectiveness of PD, but cannot yet be answered. With the lack of research underlying existing PD programs and with limited research on GMTAs, the existing knowledge base is insufficient.

To ensure that PD meets GMTA needs, we need to identify those needs; this is what I begin to do in this paper. Based on the data collected during a yearlong qualitative research study, I identified a number of GMTA needs (e.g. social networking, problem resolution, and self-efficacy), which both open discussion and research directions regarding PD. (Received September 16, 2008)

1046-U1-1916 **Craig A Swinyard*** (swinyard@up.edu), 7414 N. Chautauqua Blvd., Portland, OR 97217. *Students' Reasoning about the Concept of Limit in the Context of Reinventing the Formal Definition.*

Researchers (Bezuidenhout, 2001; Cornu, 1991) have noted the vital role limit plays as a foundational concept in analysis. The vast majority of topics encountered in undergraduate analysis are built upon understanding the concept of limit and being able to work flexibly with its formal definition (Bezuidenhout, ibid). The purpose of this study was to: 1) Develop insight into students' reasoning about limit in relation to their engagement in instruction designed to support their reinventing the formal definition, and; 2) Inform the design of principled instruction that might support students' attempts to reinvent the formal definition of limit. In separate teaching experiments, two pairs of students successfully reinvented a definition of limit capturing the intended meaning of the conventional definition. Analyses of the data generated in the teaching experiments revealed thematic elements of students' reasoning in the context of reinvention. This paper traces the evolution of the students' definitions over the course of two ten-week teaching experiments, and highlights thematic findings which point to what might be entailed in coming to reason flexibly and coherently about limit and its formal definition. (Received September 16, 2008)

Statistics in K-12 Education: How Will It Affect Statistics at the College Level?

1046-V1-195 **Anna E Bargagliotti*** (brggltti@memphis.edu), University of Memphis, Department of Mathematical Sciences, 365 Dunn Hall, Memphis, TN 38152. *Achieving Statistical Literacy in Elementary School Using Current Popular Curricula.*

In order to address the recommendations put forth by the National Council of Teachers of Mathematics (NCTM) in the Curriculum and Evaluation Standards (1989) document, several mathematics curriculum funded by the National Science Foundation (NSF) were developed. These curricula were aligned with the Principles and Standards for School Mathematics (2000). Three full elementary curricula were developed: "Math Trailblazers," "Everyday Mathematics," and "Investigations in Number, Data, and Space." These curricula have many similarities as well as differences. Math Trailblazers curriculum was developed on the idea of integrating science and mathematics. Everyday Mathematics focuses heavily on the use of manipulatives and interactive activities. Investigations develops concepts using data and focuses on understanding change. The purpose of this study was to examine the statistics content presented in each of these three curricula. Following the guidelines put forth in the Assessment and Instruction in Statistics Education (GAISE) Report: A Pre-K-12 Curriculum Framework, each curricula was studied to understand if and how the guidelines in the GAISE report were met. The objective of the study was to determine if these curricula help achieve statistical literacy in the future. (Received August 17, 2008)

1046-V1-1649 **Patricia Humphrey*** (phumphre@georgiasouthern.edu), Department of Mathematical Sciences, PO Box 8093, Statesboro, GA 30460-8093. *They Took AP, but Didn't Pass. Now What?* Preliminary report.

Approximately 110,000 students took the AP Statistics exam in 2008. In 2007 (the latest year that statistics are available), approximately 42% of the 94,000+ who took the exam scored less than a 3, the minimal "passing" score. No published information is available on the numbers of students who took the course and didn't take the test. I have seen many students of both types in my courses in recent years.

Considering that the AP syllabus includes topics not included in many introductory statistics courses, should we treat these students differently from those who perhaps failed at our institution earlier? If so, how? The goal is to keep students' interest levels high and not appear too repetitive. I'll discuss some strategies that seem to succeed, including a "one-room schoolhouse" approach. (Received September 16, 2008)

1046-V1-1792 **Rebecca A. Nichols** (rebecca@amstat.org), 732 N. Washington Street, Alexandria, VA 22314, **Martha B. Aliaga** (martha@amstat.org), 732 N. Washington Street, Alexandria, VA 22314, and **Katherine T. Halvorsen*** (khalvors@email.smith.edu), Department of Mathematics and Statistics, Clark Science Center, Smith College, Northampton, MA 01063. *The American Statistical Association's Meeting Within a Meeting (MWM) Workshop and Follow-up Activities for K-12 Mathematics and Science Teachers: An Example K-12 Statistics Education Outreach Program.*

The Meeting Within a Meeting (MWM) Workshop for K-12 Mathematics and Science Teachers is held in conjunction Joint Statistical Meetings to enhance understanding of statistics and provide activities to strengthen teaching of statistics within the math and science curriculum. Teachers apply concepts in the Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report: A Pre-K-12 Curriculum Framework (www.amstat.org/education/gaise) by exploring problems that require them to formulate questions, collect, analyze, and draw conclusions from data. MWM provides participants with a network of statisticians and educators to assist in developing the quantitative literacy of their students. This presentation will discuss the 2007 and 2008 Meeting Within a Meeting workshops and follow-up programs as an example K-12 statistics education outreach program. Plans for the upcoming MWM 2009 program will be presented. Resources related to the Meeting Within a Meeting outreach program, such as webinars, the Statistics Education Web (a developing online resource of peer-reviewed K-12 lesson plans), Statistics Teacher Network newsletter, and the ASA poster and project competitions for K-12 students will also be briefly mentioned. (Received September 16, 2008)

1046-V1-1830 **Kady Schneiter*** (kady.schneiter@usu.edu), Department of Math and Stats, Utah State University, 3900 Old Main Hill, Logan, UT 84322, and **Brynja Kohler** (brynja.kohler@usu.edu), Department of Math and Stats, Utah State University, 3900 Old Main Hill, Logan, UT 84322. *Preparing Pre-service Secondary Math Teachers to Teach Statistics.*

In response to the growing need for secondary mathematics teachers who are willing and able to effectively teach statistical concepts, we are integrating methods for teaching statistics into our mathematics teaching methods course for pre-service secondary mathematics teachers. In addition to learning about appropriate teaching methodology, our goals for the students include that they will be aware of similarities and differences in approaches to mathematics and statistics teaching, that they will appreciate the need for statistical literacy, and that they will increase their own understanding of statistical principles. We work to achieve these goals through a combination of teacher led discussions and student presentations. The course is jointly taught by a mathematician and a statistician with interests in mathematics and statistics education. We will present an outline of the course, describe lessons learned from our experience with this integrated course, and discuss student response and recommendations for future efforts. (Received September 16, 2008)

1046-V1-1854 **Lothar A. Dohse*** (dohse@unca.edu), UNC - Asheville, CPO #2350, Asheville, NC 28804. *Wikis, Forums, and Group Assignments: Building a Learning Community over the Internet.* Preliminary report.

Developments over the past years have changed the paradigms of adult education. These include: the increased importance in the management and understanding of data, the introductions of new technologies that allow modern teaching pedagogies to be delivered over the Internet, and the changes in economic realities that make commuting unaffordable to some. These new realities both create a need and offer the opportunity for the development of quality distance education statistics course for K-12 teachers.

The speaker will present a model web-based course designed for K-12 teachers who do not have the option of participating in traditional class. The course includes modern communication tools such as wikis and discussion forums that foster learning communities even among widely dispersed individuals. The implementation of these innovations will be discussed, and examples of student activities and their results will be shown. (Received September 16, 2008)

Statistics Resources on the Web

1046-W1-1172 **Mark H. Inlow*** (inlow@rose-hulman.edu), CM 143, Rose-Hulman Institute of Technology, 5500 Wabash Avenue, Terre Haute, IN 47803. *Two Applets for Teaching IID Sampling, Sampling Distributions, and the Central Limit Theorem.*

The independent and identically distributed (IID) sample and the sampling distribution are two of the most important concepts in Statistics. The former is sometimes misunderstood (Alf and Lohr, *American Statistician*, Vol. 61, No. 1) and the latter is considered difficult to teach (Gelman, *American Statistician*, Vol. 62, No. 3). We present two applets, each illustrating one of the two main methods of acquiring an IID sample, which we find effective for presenting the sampling distribution and various aspects of it, including the Central Limit Theorem. Using one of these applets our classes play "Beat the Central Limit Theorem," a game we use to demonstrate the difficulty of constructing distributions for which the sampling distribution of the mean is not approximately normal for samples of size 25. (Received September 15, 2008)

1046-W1-1357 **Susan M Barton*** (Susan.Barton@mail.wvu.edu), Department of Mathmatics, WVU Tech, Montgomery, WV 25136. *Interactive Tools for exploring the standard normal curve and more.*

Many students have trouble working with the z-table. They can find the number on the table but they have no idea how to use it to find the probability requested. They don't know when to add 0.5000, subtract the table value from 0.5000, etc. I could not find exactly what I wanted on the web so I turned to the 2008 MAA Prep workshop "Flash in the Valley" and learned to write my own. In this talk I will discuss sources I have found on the web and introduce several interactive flash applets I wrote to address the above z-Table problem. As time permits I will discuss additional applets covering other material from introductory statistics, as well as applets I am writing (or would like to see written). (Received September 15, 2008)

1046-W1-1462 **Deborah Lurie*** (lurie@sju.edu), Dept of Mathematics and Computer Science, Saint Joseph's University, 5600 City Avenue, Philadelphia, PA 19131. *The Challenges and Benefits of Using e-books and Web Companion Sites to Organize Statistics Resources on the Web for Statistics Education.*

Many publishers of introductory statistics textbooks aim to help educators organize and select from the plethora of web- based materials by creating e-books with web-based companion sites that link the student to applets, tutorials, assessment tools, videos, case studies and data sets. The instructor gets a pre-packaged 'bag of handy tricks" without having to do any additional legwork. This presentation will focus on the experience of the presenter in adopting and implementing such a system in an introductory level statistics course. It will attempt to identify the pedagogical and logistic issues that should be considered in evaluating these packages. Specific issues to be addressed include: How steep is the learning curve for student and faculty? How much computer access is required during class time? What types of assessment tools are available? How do they handle the feedback to student? Do computer graded assignment with immediate feedback enhance learning? How difficult is to find time to teach students how to use the system when the course curriculum is already overcrowded? How good are the resources provided? Is there the capability to add additional resources? How do these systems integrate with statistical software packages? What is the student reaction to this system? (Received September 15, 2008)

1046-W1-1482 **Michael Miner*** (jcmhs77@aol.com), 65 Edenbrook Drive, Hampton, VA 23666, and **Darcel Ford** (dford64@comcast.net), 5403 Riverfront Dr., Palmyra, NJ 08065. *Utilizing Web-based Statistical Resources in Teaching Nontraditional Undergraduate Students in Online Learning Environments.* Preliminary report.

The challenges facing delivery of a statistics class to nontraditional undergraduate students in nontraditional higher education programs are especially pronounced in an online program. 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. This presentation will consider four primary methods that online resources are introduced in the online learning environment and how each of these methods serves as enablers to learning statistical concepts and methodologies. (Received September 15, 2008)

1046-W1-1646 **Mary R Parker*** (mparker@austincc.edu), Austin Community College, Northridge Campus, 11928 Stonehollow Drive, Austin, TX 78758, and **Hunter D Ellinger**. *Statistics Resources in a "Math for Practical Arts" Course.*

In our Math for Measurement course, students develop facility in dealing with approximate numbers, propagation of error through calculations on approximate numbers, modeling data with linear, quadratic, exponential, and other functional models, and also learn about other topics such as applied trigonometry. Full materials for this course are available on the web. These are available for others to use and adapt. Materials include the written text, spreadsheet examples to guide students to build their own spreadsheets for fitting functions to data, and notes for teachers. Some of the materials could be useful for elementary statistics students who want to explore regression using non-linear models. (Received September 16, 2008)

1046-W1-1686 **Rob Eby*** (jeby@blinn.edu), Mathematics Division, PO BOX 6030, Bryan, TX 77805. *A collection of resources for use in teaching statistics, including assessments, group activities, in and out of class calculator simulations, and several applets to demonstrate statistical concepts.*

This presentation will present resources on the web for several different aspects of teaching. Some of these sites are alternative assessment ideas, some are alternative teaching methods. Others include ideas and lessons for group activities to improve conceptual understanding. One site has a number of calculator simulations for use either in class or as homework with a croup component. Other sites presented contain programs or simulations that can be used to enhance student understanding. As time permits, a brief discussion of the pedagogy involved in using these sites, the results of using these sites, and any suggestions gleaned from personal experience will be shared. In addition, some of the sites discussed contains articles related to the idea of conceptual understanding in Statistics and have some suggestions for implementing different approaches. Handouts containing the links and summary suggestions will also be provided. (Received September 16, 2008)

1046-W1-2031 **Robin H Lock*** (rlock@stlawu.edu), Dept. of Math, CS & Statistics, St. Lawrence University, Canton, NY 13617. *Should Statistics Tables be Banned from the Curriculum?*

Has the time arrived for "back of the book" statistics tables to follow the path of log and trig tables into extinction? We will argue that the continued use of paper-based stat tables hampers student learning while electronic alternatives available in calculators, statistical software and web applets are becoming increasingly more convenient and better suited to help students understand statistical ideas. (Received September 16, 2008)

Teaching Calculus in High School: Ideas that Work

1046-X1-69 **Carlos R. Bovell*** (carlosbovell@yahoo.com). *Developing an interest in the conceptual meaning of calculus.* Preliminary report.

The intermediate value theorem (IVT) is more often than not given in algebraic terms and then presented visually using Cartesian graphs. With the help of these two modes of presentation, the student is then encouraged and expected to apply the theorem numerically. Yet how might students be taught to process the theorem conceptually? Last year I experimented with an imaginative foray into a contemporary debate in epistemology and the students found it to be particularly illuminating for conceptually understanding and verbally articulating the substance of the IVT. After presenting and explaining an argument against fallibilism to my students, I asked them whether one of its key theses had any merit. They typically answered in the negative, although they generally found the matter of articulating specific reasons for their negative answer to be surprisingly difficult. And so I set out to express their negative answer in terms of a conceptual application of the IVT to epistemology. The students were particularly impressed with the potential relevance of the IVT to a totally unrelated field like philosophy. More importantly, the students began to develop an active interest in how to understand calculus conceptually. (Received July 21, 2008)

1046-X1-359 **Gail Kaplan*** (gkaplan@towson.edu), Towson University, Department of Mathematics, 8000 York Road, Towson, MD 21403. *The Aha! Experience in AP Calculus: Projects Designed for a Stimulating Journey on a Road of Discovery.* Preliminary report.

"All genuine learning comes about through experience." says John Dewey. Learning mathematics is not a spectator sport. The primary objective of my quest for an alternative approach to teaching advanced placement calculus in the high school classroom focused on vigorous student participation in the learning process. The basic philosophy is for students to examine examples, make conjectures, consider further examples, modify conjectures, and hopefully, have an "Aha!" experience. The majority of class time is spent with students working in groups on projects which lead the students to "discover" the next calculus concept to be covered. After a project is completed, we discuss the ideas and justify them. The students already believe and understand the major concepts because they have created them during the project. Thus, when we prove a theorem the student is able to concentrate on the justification, rather than what the theorem means. The words of one student provide a perfect summary, "You really understand the concept well by the time you finish. In order to finish, . . . you need to come up with the concept yourself and this makes it easier for you to use it in the future, . . .The element of discovery involved gives you self confidence . . ." (Received August 27, 2008)

1046-X1-476 **H. Smith Risser*** (hrisser@mtech.edu), Department of Mathematical Sciences, 1300 West Park, Butte, MT 59701. *Let them eat cake: an introduction to volumes by cross section.*

For this activity, students estimate the volume of a cake using cross sections. The activity was used to introduce volumes by cross sections. This activity was designed to strengthen students' ability to visualize the cross sections of solids and to give students a better understanding of the formula for volumes by cross section. The activity can be done in a 50 minute class period. An extension to the activity that was done as an out of class project will also be presented. (Received September 04, 2008)

1046-X1-544 **Ryo Ohashi*** (ryoohashi@kings.edu), King's College, Department of Mathematics, Wilkes Barre, PA 18711. *Teaching Calculus Course using Creative hands-on Activities.* Preliminary report.

Students often have a hard time to understand abstract mathematics theories. In particular, it is common when we teach a beginning calculus course. Some of topics the students struggle to understand are: a concept of Riemann sums, areas between curves or solids of revolution, alias volume problems. I will bring and show you some cool gadgets I use for my in-class demonstrations to explain such the concepts. These gadgets are low tech devices that use no more than strings, food, a toilet plunge, party favorites and Play Doh. The audiences will notice that my hand-on demonstration helps students truly "see" and "feel" ideas of these theories.

My teaching strategies are not only used in high school calculus but they are also utilized in college classrooms, thus university faculty members or graduate teaching assistants are also welcome to attend. (Received September 07, 2008)

1046-X1-915 **Queen W. Harris*** (Queen.Harris@gpc.edu), 2019 Emerald Drive, Jonesboro, GA 30236. *A Substitute for the U-Substitution.*

Participants will see an amazing technique used in integration when u-substitution might be a method of choice. This innovative method saves students time and leaves teachers excited about grading homework! WOW! (Received September 12, 2008)

1046-X1-967 **Mark Howell*** (mhowell@gonzaga.org), Gonzaga College High School, 19 Eye St NW, Washington, DC 20001. *Introducing Series Using Error.*

What's so special about the tangent line? Any line that intersects a curve at a point can be used to approximate the curve.

Using a grapher to zoom in on error functions, the answer to this question becomes obvious. Moreover, the methodology invites analysis of higher degree polynomial approximations.

The technique involves defining a function, f(x), a tangent line at x=a, t(x), and some other line that intersects f at x=a, w(x). Graph the two error functions, te(x) = t(x) - f(x) and we(x) = w(x) - f(x) in a window centered at (a,0). Then zoom in, first with equal scaling horizontally and vertically. You should see the graph of we(x) flatten out. This observation suggests that the function exhibits behavior greater than degree one. By changing the zoom factors, you can discern exactly what degree describes the error's behavior.

The next step is to find a quadratic function with the same output,slope and second derivative as f at x = a. and another quadratic with the same output and slope but whose second derivative differs from f's. As before, define error functions involving these two quadratics, and repeat the zooming analysis. (Received September 13, 2008)

1046-X1-1214 **P. M. Dearing** and **Shari Prevost*** (sprevos@clemson.edu), Clemson University, Department of Mathematical Sciences, Martin Hall, Box 340975, Clemson, SC 29634-0975. *The Clemson Calculus Challenge: A Calculus Competition for High School Students.* Preliminary report.

The Clemson Calculus Challenge (CCC) is a one-day calculus contest for high school students that is held each spring at Clemson University. The CCC provides a forum for mathematically interested high school students to compete against one another and showcase their calculus talents in both an individual event and a team competition. (Received September 15, 2008)

1046-X1-1235 **Mary Ann Connors*** (mconnors@wsc.ma.edu), Department of Mathematics, Westfield State College, Westfield, MA 01086. *Modeling the Spread of a Disease.*

Can you use your mathematical skills to model the spread of a disease to make predictions about how long it will take before an entire population is infected? This session will present a way to simulate the spread of the disease and come up with possible solutions and predictions. We will investigate the problem using derivatives and ordinary differential equations. (Received September 15, 2008)

1046-X1-1333 **Aldo Maldonado*** (aldo.maldonado@gmail.com), 15300 Cadoz Dr., Austin, TX 78728. *Metaphors that work, calculus and the real world.*

Author describes how some ideas from outside of mathematics can be used to help students see through some concepts in calculus and mathematical analysis like finite limits and convergent infinite series. Author will describe some simple ideas from circuit design and quality control, and other areas that can be used in the classrooms to easy students to some critical calculus concepts. (Received September 15, 2008)

1046-X1-1590 **Christine M Malone*** (malonec@wcs.k12.mi.us), 27500 Cosgrove, Warren, MI 48092, and **Marie B. Copeland** (marcop@wcs.k12.mi.us), 27500 Cosgrove, Warren, MI 48092. *Written Papers and Oral Examinations to Deepen Students Understanding of Calculus.*

Students write four papers, based on questions similar to the released free-response questions of previous AP exams. Topics include such things as methods of finding solids of revolution, relationships between graphs, derivatives and integrals, Riemann sums, definite integrals, and first and second derivatives. The papers require that students think deeply about the underlying calculus principles. They must describe these concepts in their own words and show a step-by-step solution to each problem that involves these topics.

An oral examination of each student is conducted by a panel of three outside experts. The panel includes retired teachers, engineers, and other professionals from the community. The panel chooses a paper from among the four previously prepared, and poses questions to the student to assess his/her understanding. Having to communicate their understanding of calculus to unknown adults in a formal setting requires good communication skills and thorough preparation.

Students report benefits to this process: They solidifed their understanding prior to the AP exam. They applied the oral communication skills to other areas (job interviews, professor contacts, etc.) They referred to their papers when they took Calculus 2 or 3 at the university. (Received September 16, 2008)

1046-X1-1883 **Robert Sachs*** (rsachs@gmu.edu), Department of Mathematical Sciences, George Mason University, MSN 3F2, Fairfax, VA 22030. *Teaching series convergence effectively.*

The experience of teaching power series in high school to highly advanced students in a later course (complex analysis) over the past eight years has led me to present the material in a somewhat novel way. Emphasizing the relative size of terms cuts through the fog. The key ideas apply to real power series directly. The starting point is to recognize the exponential nature of the geometric series. The size of $n!$ enters as well. My university teaching of calculus using this approach has been very successful with a general university student population also. (Received September 16, 2008)

1046-X1-1927 **Doug Kuhlmann*** (dkuhlmann@andover.edu), 20 Hidden Field Rd, Andover, MA 01810. *Numerical Integration before Antidifferentiation.*

For several years I have introduced numerical integration including the trapezoid rule, midpoint rule and Simpson's rule before studying antidifferentiation and indefinite integrals. Using a simple student written program on a TI-83/84, students can discover the Fundamental Theorem of Calculus. A major benefit is that students learn that a definite integral is a number, not a class of functions. (Received September 16, 2008)

Undergraduate Mathematical Biology

1046-Y1-176 **Sheldon P. Gordon*** (gordonsp@farmingdale.edu), Department of Applied Mathematics, Farmingdale State College, Farmingdale, NY 11735. *Modeling Logistic Growth and Extinction.*

Most of the introductory treatments of models for population dynamics in mathematics classes typically consider only population growth models such as exponential growth and logistic growth. However, biologists have observed that not only is there a maximum sustainable population level (as in the logistic model), but also a minimum sustainable population level and if the population falls below this, it will eventually become extinct. In this talk, the presenter will construct a pair of more general population models based on both difference equations and differential equations that encompass the possibility of both growth and extinction. (Received August 12, 2008)

1046-Y1-289 **Jennifer R. Galovich*** (jgalovich@csbsju.edu), Department of Mathematics, St. John's University, Collegeville, MN 56321-3000. *Bioinformatics on the Cheap.*

Teaching bioinformatics could be a departmental budget buster for the purchase of new software. This talk will describe how I dodged this problem using tools available for free on the Internet. I will also describe some of the projects students completed using such tools. (Received August 25, 2008)

1046-Y1-548 **Brian Hopkins*** (bhopkins@spc.edu). *The Standard Genetic Code and Equivalence Classes.*

There are 20 amino acids used by cells to create proteins. These are signaled by codons in RNA, which can be thought of as three letter words over the alphabet $\{A, C, G, U\}$. How do the 64 possible codons correspond to the amino acids? We detail a project where students explore various equivalence classes on codons before examining the actual standard genetic code. This project has been successfully used in discrete mathematics and in mathematical modeling courses. It was inspired by the presenter's participation in the Faculty Resource Network's seminar Bio 2010: Integrative Approaches to Teaching Science held in 2005 at New York University. (Received September 07, 2008)

1046-Y1-993 **Brynja R Kohler*** (Brynja.Kohler@usu.edu), Department of Mathematics and Statistics, 3900 Old Main Hill, Logan, UT 84322, and **Rebecca J Atkins**, **James Haefner** and **James Powell**. *Secret Diffusion Lessons of the Sea Monkeys and Other Math Bio Projects for Undergraduates.*

In this presentation, we provide a description of labs and lessons that can be integrated into a variety of mathematics courses in which students have the opportunity to develop an understanding of the diffusion equation as a model of random motion. The labs require students to collect data on the movement of brine shrimp (a.k.a. Sea-Monkeys), fit parameters, and do a validation study and sensitivity analysis on the model. We have found that involving students in the experimental design and data collection not only helps them build their understanding of the diffusion equation and its solution in an engaging and enjoyable way, but it provides an excellent pedagogical opportunity to bring authentic work of applied mathematics, interdisciplinary collaboration, and modeling to a university course. We will share specific course materials developed for this and other mathematical biology projects designed and tested in undergraduate courses at Utah State University. (Received September 13, 2008)

1046-Y1-1014 **Steven M Deckelman*** (deckelmans@uwstout.edu), 237 Harvey Hall, Menomonie, WI 54751. *Sensitivity Analysis and Parameter Identification in Undergraduate Mathematical Modeling.*

Sensitivity analysis of parameters in mathematical models is becoming increasing important in mathematical modeling, especially in mathematical biology. Curiously, although well known in the electrical engineering and control theory literature, sensitivity analysis does not seem to be well represented in the undergraduate mathematical modeling literature. This talk will describe some of the basic concepts of sensitivity analysis in the language of undergraduate mathematical modeling. We will also point out the some of the connections between sensitivity theory and the fundamental problem of identifying model parameters. These concepts will be illustrated using the classical SIR model for epidemics. (Received September 13, 2008)

1046-Y1-1234 **Timothy D Comar*** (tcomar@ben.edu), Department of Mathematics, Benedictine University, 5700 College RD, Lisle, IL 60532. *Activities Designed to Prepare Undergraduates for Research in Mathematical Biology.*

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 15, 2008)

1046-Y1-1275 **Margaret M Sullivan*** (msullivan@ndm.edu), 4701 North Charles Street, Baltimore, MD 21210. *BioCalculus: First Steps at a Small Liberal Arts College.*

Small liberal arts colleges usually do not have the option of creating BioCalculus courses in addition to the traditional Calculus sequence although often a majority of their Calculus I and II students are interested in the Biology major. This paper discusses one small liberal arts institution's efforts to bridge the gap between calculus and biocalculus. The discussion will focus on materials developed for use in the laboratory sessions for Calculus I. These materials have their origin in topics discussed and ideas garnered at the MAA PREP BioCalculus workshop in June 2008. (Received September 15, 2008)

1046-Y1-1567 **Kelly E Matthews*** (k.matthews1@uq.edu.au), **Merrilyn Goos** and **Peter Adams**. *Translating the principles of BIO2010 into practice.*

The University of Queensland in Brisbane, Australia is a large, research-intensive institution. A recent review of the Bachelor of Science, which was strongly influenced by BIO2010, resulted in a more quantitative program. While our academic staff supported the underlying message of BIOL2010, the translation of this message into practice has been challenging. This challenge has been exemplified in the development and implementation of a new first year course, SCIE1000, which is taught to over 500 students. The course aims to demonstrate 1) the interdisciplinary nature of science; 2) how mathematics underpins various scientific disciplines; and 3) the role of computational modelling in scientific research. This talk will focus on materials developed for this course. Additionally, materials will be presented and discussed in the context of how these where developed, how students perceived them, and how students performed when using them. The challenges of creating an interdisciplinary (mathematical/computational/general science) course will be explored with insight into the types of academic development opportunities that aided the course coordinators. Finally, details will be provided on how participants can access more of the materials used in SCIE1000. (Received September 16, 2008)

1046-Y1-1606 **Jeff R Knisley*** (knisleyj@etsu.edu), Box 70663, Dept. of Math, East Tennessee State University, Johnson City, TN 37614-0663. *Active Learning in the Symbiosis Project.*

The Symbiosis project is an HHMI-funded response to the BIO2010 report that integrates biology, calculus, and statistics within an introductory laboratory science course. Active learning and inquiry-based investigation are featured throughout the curriculum, often as a means of introducing, developing, and assessing concepts in calculus and statistics. We describe several of the tools and techniques used to promote active learning in the Symbiosis project, with an emphasis on how scientific investigation can motivate mathematical development and how mathematical modeling and statistical inference can shape scientific pursuits. (Received September 16, 2008)

1046-Y1-1742 **Robert E. Burks Jr.*** (robert.burks@usma.edu), 211B Barry Road, West Point, NY 10996. *What's Math have to do with History: A Biological Application to Matrices and Difference Equations.*

All incoming freshmen at the United States Military Academy begin their two year mathematics sequence with a course in mathematical modeling and introduction to calculus. The course emphasizes using problem solving strategies and modeling theory to solve complex and often ill-defined problems. The course is designed to nurture creativity, critical thinking, and exploit technological tools to enhance an understanding of data analysis. The course includes several applications that focus on biological modeling applications. These applications fuses for the student mathematical concepts learned during the course with biological case problems. The intent is to continually show students the relevance of mathematics to the study of real world problems, particularly to Biology. This presentation focuses on biological application built upon previous instruction in both matrix operations and difference equations to address the spread and devastation of disease on age-structured population problems. I will discuss how our program incorporates the application of mathematics to construct Leslie and SIR Models that address historical biological case studies. (Received September 16, 2008)

1046-Y1-1987 **E Miller Jason*** (millerj@truman.edu), 100 E Normal St, Kirksville, MO 63501. *Training Undergraduates in Mathematical Biology Using Research With Faculty.*

Since 2004, Truman State University has trained students to conduct interdisciplinary research in mathematical biology through a combination of research experiences with faculty collaborators, courses, and field trips. This program of experiences for undergraduates has been made possible by the National Science Foundation's *Interdisciplinary Training for Undergraduates in Biology and Mathematics* (UBM) program. This talk will outline our courses and our research program (including a portfolio-based interdisciplinary minor in mathematical biology), what we have learned about assessing interdisciplinary learning, and the role field trips have played in the professional development of faculty and students. (Received September 16, 2008)

1046-Y1-2010 **S. Koksal*** (skoksal@fit.edu), 150 W. Univ. Blvd., Department of Mathematical Sciences, Melbourne, FL 32901. *UBM-Research and Education Program in Biology and Ecology.* Preliminary report.

In this presentation, we will talk about the NSF funded UBM program, bridge courses in order to start a research mathematical biology. How they work; how popular they are and how they are taught. In addition, examples of student research projects will be given and a newly established undergraduate progam in Mathematical Biology willbe presented. (Received September 16, 2008)

1046-Y1-2041 **J K Denny*** (denny_jk@mercer.edu), Department of Mathematics, 1400 Coleman Avenue, Macon, GA 31207. *Materials for Analyzing Sensitivity using the Partial Rank Correlation Coefficient.* Preliminary report.

The partial rank correlation coefficient (PRCC) gives a measure of the sensitivity of a differential equations model to its parameters. We will present software and materials for introducing undergraduate students to the use of Latin hypercube sampling to randomly sample a parameter space and then use the resulting information to compute the PRCC. Examples will be provided to demonstrate the use of these methods. Students should then be able to apply these techniques to their own modeling projects. (Received September 16, 2008)

Wavelets for Undergraduates

1046-YY-1362 **Katherine L McCaffrey*** (klmccaffrey@stthomas.edu), 2115 Summit Avenue #6209, University of St. Thomas, St. Paul, MN 55105, and **Nicole F Kingsley** (nfk2@geneseo.edu), Department of Mathematics, 323 South Hall, State University of New York, Geneseo, NY 14454. *Wavelets in Vocal Identification of Great Horned Owls (Part I).* Preliminary report.

Vocal Identification is a relatively new approach to tracking animal species in the wild, and is an alternative to current "catch and release" methods. In this study we explore the process of applying wavelet analysis techniques to the signal processing aspects of vocal identification. We will set up and describe the problem, discuss the necessary preliminary work including denoising and normalizing signal vectors, highlight the limitations of traditional Fourier analysis, and discuss the advantages of wavelet analysis to this type of applied mathematical problem. (Received September 15, 2008)

1046-YY-1365 **Caroline N Haddad*** (haddad@geneseo.edu), Department of Mathematics, State University of NY College at Geneseo, Geneseo, NY 14423, **Dawit Haile** (dhaile@vsu.edu), Mathematics & Computer Science, 1 Hayden Drive, Virginia State University, Petersburg, VA 23806, and **Helmut Knaust** (hknaust@utep.edu), Department of Mathematical Sciences, The University of Texas at El Paso, El Paso, TX 79968-0514. *Zooming in on a Transformed Image: a Project for Students.*

Many images from fingerprints to MRIs are compressed for storage purposes. This typically involves transforming the original image, e.g. with a wavelet transform, possibly quantizing the result, and encoding. The result after transforming involves a "blurred" version of the original and some detail data. These files are generally fairly large. Suppose one is only interested in refining some small portion of the blurred version. Is it possible to "zoom in" on the "region of interest" without inverting the entire transformed image? Such questions frequently arise, especially in the medical field. Here we present a proposed student project that addresses this problem. The project was developed in a Wavelets Module Writing Workshop in connection with the PREP workshop "Wavelets: A Multi-Disciplinary Approach". Knowledge of the Discrete Haar Wavelet Transform and its inverse, as well as some coding background is all that is required of the student. (Received September 15, 2008)

1046-YY-1441 **Nicole F. Kingsley*** (nfk2@geneseo.edu), Box 2466, 10 MacVittie Circle, Geneseo, NY 14454, and **Katherine L. McCaffrey**, 2115 Summit Ave #6209, Saint Paul, MN 55105. *Wavelets in Vocal Identification of Great Horned Owls (Part II).* Preliminary report.

Now that we have formulated the problem and established our hypothesis, we set up a wavelet packet decomposition algorithm from which we can extract features that will help determine specific characteristics of individual owl calls. These characteristics include spread, position, maximum power, and width. We will explain the derivation of these features, and how they are represented in a pseudocolor wavelet packet decomposition matrix. We will close by reporting some important results from basic statistical analysis of our data, and draw some important conclusions about the role of wavelet analysis in the vocal identification of Great Horned Owls. (Received September 15, 2008)

1046-YY-1690 **Roger Zarnowski*** (roger.zarnowski@angelo.edu), **Tatyana Sorokina** (TSorokina@towson.edu) and **David K Ruch** (ruch@mscd.edu). *A Student Project on Matrix Completion for Discrete Wavelet Transformations.* Preliminary report.

Wavelet transformation matrices for finite data are commonly constructed by wrapping the filter coefficients at the boundary rows. For data that cannot appropriately be interpreted as periodic, this results in an undesirable mixing of information from opposite boundaries. A remedy called matrix completion consists of modifying the boundary rows with a different set of coefficients, chosen to eliminate wrapping while preserving orthogonality. We describe a student project for developing matrix completions for the Daubechies D4 and D6 filters, using a CAS such as Mathematica or Matlab. The project incorporates both analysis and computation, as well as illustrative examples and an examination of certain tradeoffs that must be considered in constructing the solutions. (Received September 16, 2008)

1046-YY-1696 **David K Ruch*** (ruch@mscd.edu), Dept of Mathematics, Campus Box 38, Metropolitan State College of Denver, Denver, CO 80217. *A student summer research project on image segmentation using wavelet methods and matrix completion.*

Image segmentation is the process of splitting a digital image into multiple regions, with applications in medical imaging and manufacturing quality control. The most common image segmentation goal is to locate objects and boundaries in images. In general, this is a very difficult problem to completely automate, and there are a number of specialized techniques used in segmentation. This talk discusses results of a recent summer undergraduate research project that used wavelet methods to denoise images as part of some image segmentation methods. The technique known as matrix completion was also utilized to deal with edge problems in digital images. The project focused on digital images with two or three well-defined regions. Automated routines were developed to detect these regions with complications of mild noise and texture also in the image. This talk will refer to the material presented in "A Student Project on Matrix Completion for Discrete Wavelet Transformations" during this Special Session, Abstract # 1046-YY-1690. (Received September 16, 2008)

1046-YY-1698 **Catherine Beneteau*** (cbenetea@cas.usf.edu), **Kristin Pfabe** and **Karen Shuman**. *A Student Project on Lifting Algorithms for Wavelet Transformations.*

In this talk, we will discuss an end of semester project on lifting algorithms for students who have studied discrete wavelet transformations and their applications. In particular, we will define what lifting means, why it is useful for memory allocation and computational speed, and what some of its applications are (for example, in integer to integer transformations). In addition, we will give some concrete ideas about what a student might be expected to produce in such a project. (Received September 16, 2008)

1046-YY-1920 **Bruce Atwood** (atwoodb@beloit.edu), Box 224, Beloit College, 700 College Street, Beloit, WI 53511, **Raouf Boules** (rboules@towson.edu), Towson University, 8000 York Road, Department of Mathematics, Towson, MD 21252, and **Patrick Van Fleet*** (pjvanfleet@stthomas.edu), 2115 Summit Avenue #OSS201, Department of Mathematics, University of St. Thomas, St. Paul, MN 55105. *Wavelet Packets and Applications.* Preliminary report.

In this talk, we will discuss the design and development of a project on wavelet packets and applications. The project is designed for undergraduate students. The ideal prerequisite for the project is an elementary introduction to the discrete wavelet transformation and its applications, but a good background in sophomore linear algebra, some elementary statistics, and programming skills will suffice. We will give a brief introduction to wavelet packets and discuss ways the student group can implement them on a computer. We will conclude the talk with a discussion of an application of wavelet packets to the problem of image compression and discuss how this application can be incorporated into the project. (Received September 16, 2008)

1046-YY-1962 **Colm Mulcahy*** (colm@spelman.edu). *An Image Compression Introduction to Wavelets.*
Since the mid 1990s, inspired by Tony DeRose *et al* at the University of Washington, I've utilized an elementary approach to image compression using Haar wavelets with independent study students at Spelman College as a way to motivate key concepts in linear algebra and also expose them to modern applications of mathematics in fields such as image processing and computer graphics. Matlab is used and students respond positively to being able to manipulate their own ditigal images within a week or two of starting on the project. The traditional attack on wavelets, using advanced Fourier methods, is entirely circumvented, and the linear algebra approach also points to more advanced and more practical generalizations of the Haar wavelets. (Received September 16, 2008)

General Session

1046-Z1-19 **John F Loase*** (john.loase@concordia-ny.edu), Concordia College, 171 White Plains Rd., Bronxville, NY 10708. *The Positive Influence Generation(Our College Students).* Preliminary report.
Loase has spent 23 years in interdisciplinary study of sigfluence, his new word for significant, long-term, positive influence. Sigfluence has been scrutinized through the perspectives of Statistics, Statistical Modeling, Data Mining, Psychology, Linguistics, and several other disciplines. The validation of the survey took nearly fifteen years and was described in Loase's sixth book, Theory and Measurement of Sigfluence (University Press of america, 2000). In a recent three year study of 542 undergraduates Loase used data mining , all levels of statistics, and qualitative methods (Triad Methodology) to explore the attitudes of our current college students toward money and sigfluence. To Loase's surprise and delight, our college students appear more motivated by sigfluence than money(The Positive Influence Generation, Hamilton Books, 2007). They report very high levels of Need and Potential to effect long-term, positive influence. However, they asked for a partnership with their professors to identify avenues by which they can fulfuill this potential. Part of the lecture will include an open forum on how we professors could partner a new era with our students. (Received May 19, 2008)

1046-Z1-43 **Louis A. Levy*** (louis_levy@ncsu.edu), North Carolina State University, Department of Mathematics, Box 8205, Raleigh, NC 27695. *Multipliers for the Lower Central Series of Strictly Upper Triangular Matrices.*
Lie algebra multipliers and their properties is a recent area of study. A multiplier is the Lie algebra analogue of the Schur multiplier from group theory. By definition a multiplier is central, so we only need to find its dimension in order to characterize it. In this talk we will investigate how to find the dimensions of the multipliers for 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 matrix and the position in the series. (Received July 01, 2008)

1046-Z1-46 **James R. Henderson*** (henderso@pitt.edu), 306 N. Franklin Street, Titusville, PA 16354. *What Is a Mathematical Theory?*
It is currently fashionable among some philosophers to try to understand mathematics as an empirical science rather than as a purely formal undertaking. If one assumes this point of view, it is possible to learn much from earlier work done in the philosophy of science where physics, chemistry, biology, and other sciences traditionally taken to be empirical were under consideration. In particular, the question "What is a scientific theory?" has received much attention in this context. The logical positivists took theories to be partially interpreted axiomatic systems with both observational and theoretical terms; this is the syntactic view of theories due to Carnap and others. On the other end of the spectrum is the semantic view, due to van Fraassen and others, which takes theories to be identified with their associated sets of models. Not surprisingly, many positions between these two extremes have been staked out. This essay, relying in part on Bueno's extension of Quine's indeterminacy thesis rules out the syntactic view for mathematical theories and seeks to show that many of the arguments used against the semantic view lose their force in a mathematical setting. Thus, an interpretation between these extreme views is not needed. (Received July 03, 2008)

1046-Z1-65 **Kevin Yorke Kelbaugh*** (kkelbaug@gmu.edu), 4400 University Drive, Mathematical Sciences, George Mason University, Fairfax, VA 22030, and **Minerva Venuti** and **Padmanabhan Seshaiyer**. *Fluid-structure interaction mathematical models for studying biological systems.* Preliminary report.

This undergraduate research paper presents mathematical models for the interaction of blood flow with the arterial wall surrounded by cerebral spinal fluid. The blood pressure on the inner arterial wall is modeled using 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 both using analytical and computational tools. Applications of the model studied to intracranial saccular aneurysms will be presented. (Received July 18, 2008)

1046-Z1-67 **Morteza Shafii-Mousavi*** (mshafii@iusb.edu), Mathematical Sciences, PO Box 7111, South Bend, IN 46634-7111. *Spreadsheet Modeling and Applications.*

The paper describes Spreadsheet Modeling and Software demos used in teaching Mathematical Modeling courses offered for math, science, and education majors. Courses teach the concepts and methods of mathematics as aids to understanding and solving problems arising in the life, social sciences, and business. Throughout each course, I use software and adopt a spreadsheet-based approach to the modeling as tools to facilitate the study, implementation, and evaluation of models. Student projects are significant parts of the courses. Each project is a realistic case of a complex situation. Spreadsheet modeling demos allows students to think through complex problems, identify decision variables, write constraint equations, analyze large data sets, utilize math and statistical functions, perform tedious computations, write reports, and prepare presentation materials. The paper emphasizes how I teach by examples and adopt a practical spreadsheet-based approach to the modeling of a wide variety of problems from finance, optimization, and operations; how it fits into the courses; the affect it has had on student attitudes toward mathematics; how it puts the entire problem solving approach within the capability of all students; and a summary of assessment techniques employed in the courses. (Received July 19, 2008)

1046-Z1-71 **Carlos R. Bovell*** (carlosbovell@yahoo.com). *What is mathematics and what kind of answers will satisfy this question?*

What is mathematics? When some respond to this question, they urge that the answer must be meaningful to "working mathematicians": they say that if one is interested in knowing what mathematics is then that person should begin by looking at what mathematicians do. But this helpful first step has led to the suggestion that mathematics is what mathematicians do. Yet doing mathematics is a first-order activity and inquiring into what mathematics is is a second-order activity. Discussions treating the relationship between first- and second-order activities go at least as far back as Plato's dialogues. In my talk, I argue that Socrates was right being unsatisfied with first-order answers to his second-order questions. He correctly surmised that his second-order questions are of a rather different sort than their first-order counterparts. In much the same way, any answer that boils down to "mathematics is what mathematicians do" cannot prove altogether satisfactory as a response to the question, "what is mathematics?" (Received July 21, 2008)

1046-Z1-79 **Michelle R DeDeo*** (mdedeo@unf.edu), Department of Mathematics and Statistics, 1 UNF Drive, JACKSONVILLE, FL 32224. *Incorporating Software into College Algebra: Who Wins? We All Do, If...*

Seven years ago, my paper entitled Improving Pass Rates in Mathematics using Interactive Software was published in Selected Papers from the Twelfth National Conference on College Teaching and Learning gave a positive assessment of the use of software as a component in the teaching of College Algebra. The paper supported the idea that interactive mathematics software promotes increased retention and success for students in College Algebra courses and those students were engaged in learning at school and at home.

In 2006, not only was this initial data confirmed, but one particular system proved to be more successful, more flexible and a better fit than the other systems that were tested. This talk updates those results and discusses the continued success.

We evaluate a total of seven years worth of study, present student and instructor feedback and compares how well the students performed in sections that utilized software versus (1) those instructors who made use of the system optional and (2) those that did not use the system. (Received July 21, 2008)

1046-Z1-111 **Raymond N Greenwell*** (matrng@hofstra.edu), 103 Hofstra University, Hempstead, NY 11549. *Statistical significance of ranking paradoxes.* Preliminary report.

Haunsperger (2003) has shown that when the Kruskal-Wallis nonparametric statistical test on n samples 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. We further investigate these ranking paradoxes by showing that when they occur, the differences in ranking are not statistically significant. (Received July 23, 2008)

1046-Z1-112 **A. Dale Magoun*** (magoun@ulm.edu), The University of Louisiana @ Monroe, Dept of Mathematics and Physics, Monroe, LA 71209-0575, **A. Serpil Saydam** (saydam@ulm.edu), The University of Louisiana at Monroe, Dept of Mathematics/Physics, Monroe, LA 71209, **Charlotte H. Owens** (owens@ulm.edu), The University of Louisiana at Monroe, Dept of Mathematics/Physics, Monroe, LA 71209, **Elizabeth T. Smith** (bsmith@ulm.edu), The University of Louisiana at Monroe, Dept of Mathematics/Physics, Monroe, LA 71209, and **Stephen Richters** (magoun@ulm.edu), The University of Louisiana at Monroe, Provost, Monroe, LA 71209. *Integrating College Algebra with Modularity and Technology (iCAM&T): A first year Follow-up.* Preliminary report.

Integrating technology into the college classroom has recently received much attention from the National Center for Academic Transformation (NCAT). Under their roadmap to redesign (R2R) criteria, mathematics classrooms at many universities have incorporated new approaches to student learning. This paper discusses each of the major components of designing a new modular, technology-based curriculum, the development of a mathematics resource center to support the curriculum, and the first year results of the implementation of R2R at our university. (Received July 23, 2008)

1046-Z1-147 **Kyle L Riley*** (Kyle.Riley@sdsmt.edu), Dept. of Math & Computer Science, SDSM&T, 501 East Saint Joseph Street, Rapid City, SD 57701. *The Role of External Consultants as Part of a Departmental Self Study.*

The MAA Guidelines for Programs and Departments in the Undergraduate Mathematical Sciences recommends that departments conduct regular reviews. Moreover, the guidelines indicate these reviews should enlist external consultants from the mathematics profession. This talk will seek to outline strategies that will enhance the role of the consultant in the self-study process and suggest general indicators that a consultant should look for at the initial stages of the process. (Received August 06, 2008)

1046-Z1-150 **Sarah J Greenwald*** (greenwaldsj@appstate.edu), 121 Bodenheimer Drive, 326 Walker Hall, Boone, NC 28608, and **Gregory Rhoads**. *Historical Resources for Multivariable Calculus and Differential Geometry.*

In the MAA Curriculum guide from 2004, the Committee on the Undergraduate Program in Mathematics (CUPM) recommends that mathematics programs “guide students to learn mathematics in a way that helps them to better understand its place in society: it’s meaning, its history, and its uses” in order “to serve all students well - not only those who major in the mathematical or physical sciences.” Teaching history in the context of courses will help all of our students to see history, especially those who are unlikely to take a course in the history of mathematics.

We have created a searchable website containing a collection of historical resources related to multivariable calculus and differential geometry. The user can search to find articles or content that relate to the history of a topic along with activities for incorporating history into these classrooms.

We will make the site publicly available as we discuss our work and share what we have learned. (Received August 06, 2008)

1046-Z1-165 **Murray H. Siegel*** (murray.siegel@centralaz.edu), 20159 N GEYSER DRIVE, Maricopa, AZ 85238. *Discovering the Derivative and Its Meaning with the Graphing Calculator.*

Students tend to master a concept more successfully if they can discover the concept. Many calculus students memorize the definition of the derivative, learn various rules for taking the derivative of specific functions but never internalize the meaning of this valuable tool. A graphing calculator is used in a 5-step process to "discover" the derivative of common functions. First the student graphs the function and decides where the derivative should be positive, where zero and where negative. The 2nd step is to replace "h" in the definition of the derivative with .0001. The 3rd step is to graph this derivative function. The next step is to determine what function would provide such a graph and validate that this is the derivative of the original function by graphing it on top of the function found in step 3. Finally the graph of the derivative is examined to insure that it meets the criteria established in step 1. The class works through a number of different functions and then examines more functions for homework. Once the class is satisfied that they have identified the derivatives, the definition of the derivative is used to prove that the discovered derivative is correct. (Received August 08, 2008)

1046-Z1-167 **William M. Wagner*** (wwagner1@columbus.rr.com), c/o Kathryn L. Wagner, 7199 Dublin Rd., Dublin, OH 43017-1164. *Continual Compounding of a Conventional Mortgage.*

Definitions:

L: Mortgage Loan; e.g. \$100,000.

T: Term in periodic units of time; e.g. 15 years.

R%: Rate of periodic interest; e.g. 6% per annum.

A: Amount of payment due at the end of one unit of time.

P: Instantaneous Principal.

The recursion relation for discrete compounding is $P(i+1) = P(i)[1 + R\%/m]$ where m is the number of payments (intervals) per unit of time; compounding occurs at the end of each such interval. As the cycle, $(1/m)$,of compounding and payments approaches infinity, the resulting limit is the first order linear Ordinary Differential Equation: $-dP/dt = -R\%P + A$ The Integration Factor for this O.D.E. is $EXP(-R\%t)$. It shall be shown that:

I. The amplication factor of the Loan for total payments is $(AT/L) = R\%T/[1 - EXP(-R\%T)]$; (Here, the total payment is \$151,660.60-.)

II. Integral $[0, T; (-R\%P + A)] = L$; (This is analogous to the fact that, under discrete existense, the sum of the reductions in principal is equal to the Loan.)

III. The total interest $(AT - L) = R\%Integral[0, T; P]$. (Received August 10, 2008)

1046-Z1-168 **Hurlee Gonchigdanzan*** (hurlee@uwsp.edu), Department of Mathematical Sciences, University of Wisconsin - Stevens Point, Stevens Point, WI 54481. *Limit theorems for the product of partial sums.* Preliminary report.

Let $X_1, X_2, \ldots$ be a sequence of independent and identically distributed positive random variables with mean $\mu > 0$ and variance σ^2. Let $S_n = X_1 + X_2 + \cdots + X_n$. In recent years many interesting results have been obtained on the asymptotic behavior of the product of the partial sums, $\prod_{k=1}^{n}(S_k/\mu k)$, under a certain normalization.

We will discuss about an almost sure limit theorem for the products of the partial sums and will give a necessary and sufficient condition for the functional version of the theorem. (Received September 11, 2008)

1046-Z1-172 **Timothy G Hall*** (info@pqic.com), PQI Consulting, P. O. Box 425616, Cambridge, MA 02142-0012. *Synthetic Mathematical Thought.*

Many grand achievements and breakthroughs in mathematics as well as in the sciences have been inspired by simply reading the past ideas of authors long gone, whose work has planted the seeds of new, greater ideas in the next generation of mathematicians and scientists. With the incredible library of mathematical thought now available through electronic communication, perhaps it is time to let those electronic machines assist the human mind in mathematical discovery by accentuating what computers do best: The rapid, accurate, and precise manipulation of incremental pieces of information in coded form. In support of advancing this noble effort, would electronic computing not be an excellent tool to quickly, precisely, and accurately search through potentially an unlimited number of mathematical expressions, searching for patterns, compatible material, and linked conditional statements? Perhaps to alert a mathematician to an intricate conclusion that may be valuable in its own right, but which may never have been found due to its obscure pedigree? This paper presents the foundations for implementing synthetic mathematical thought in a modern computing environment, along with some proposed nomenclature and logical processes. (Received August 11, 2008)

1046-Z1-184 **Peter T Olszewski*** (polszewski06@yahoo.com), 18 Sheephill Road, Riverside, CT 06878. *Group Presentations, Cayley Graphs, & Markov Processes.* Preliminary report.

The purpose of this talk is to examine the relationship between groups, group presentations, their Cayley graphs, and associated Markov Processes. In particular, we prove that for a finite group derived from an ergodic Markov Process, a process we describe in this talk, the long-range equilibrium vector is uniform on the group elements, as to be expected. We also prove a theorem giving a complete characterization of finitely generated free groups in terms of their associated Markov Processes. (Received August 13, 2008)

1046-Z1-228 **Jennifer D. Wagner*** (jennifer.wagner1@washburn.edu), Department of Mathematics and Statistics, Washburn University, 1700 SW College Ave., Topeka, KS 66621. *Evaluating Communication Skills in a Modern Algebra Course.* Preliminary report.

When teaching Modern Algebra, I want to improve my students' skills in communicating mathematical ideas. To this end, I incorporated both speaking and writing about mathematics into the course grade. I'll talk about what I did and how the students reacted. (Received August 20, 2008)

1046-Z1-236 **Paul Raymond Bouthellier*** (pbouthe@pitt.edu), 504 East Main Street, Titusville, PA 16354. *Illustrating Algorithms for Computing Computer Graphics.* Preliminary report.

This talk is applicable to all classes and students who use calculators and computers for computation and graphics. Our objective is to use computer graphics to show how mathematics is used to power the machines that students use every day.

We shall look at calculating elementary functions using methods such as table-lookup algorithms and minimax polynomials for the purposes of graphing on computers. As computers depend on pixels for graphing, algorithms only need do enough calculations to be accurate to within a pixel-which sets the accuracy required by the algorithms. The number of calculations needed for computing the sine, cosine, and tangent functions to the degree of accuracy required for graphing will be computed and illustrated. The same results will be used to compute sine and cosine values for rotation matrices in R2 and R3 using a minimal number of computations to get accurate rotational results.

The algorithms and graphics will be illustrated using Flash CS3. (Received August 21, 2008)

1046-Z1-239 **Pamela K Wovchko*** (wovchko_p@wvwc.edu), Buckhannon, WV 26201. *Elementary Statistics: To Lecture or Not To Lecture? That is the question.*

As part of an NSF Curriculum Development grant, elementary statistics classes at West Virginia Wesleyan College were taught using different techniques during the 2007-2008 academic year. One semester, an activity-based, non-lecture style was implemented. The other semester, a traditional lecture method was used. Students were given a pre-test, a post-test, and a brief questionnaire about their learning experience. The statistical results are in; come find out the results. (Received August 21, 2008)

1046-Z1-248 **Jay L. Schiffman*** (schiffman@rowan.edu), Rowan University, 201 Mullica Hill Road, Glassboro, NJ 08028-1701. *Exploring Goldbach's Conjecture Via CAS (Computer Algebra System)Technology.* Preliminary report.

Goldbach's Conjecture asserts that every even integer > 2 can be expressed as the sum of two primes. Another version of this conjecture is that every odd integer > 5 can be expressed as the sum of three primes. In this paper, simple programs for a CAS capable calculator such as the TI-89 or VOYAGE 200 will be discussed to enable undergraduate and pre-service students to obtain a better grasp of this simply posed open problem in elementary number theory. While this conjecture remains unresolved since the time of Leonhard Euler, the crux of the problem is readily accessible to any good middle school or high school student. (Received August 22, 2008)

1046-Z1-335 **Ellen Mir*** (emir@elon.edu), CB 2320, Elon, NC 27244. *Incorporating Mathematics into a Study Abroad Experience.*

This talk will describe a 3-week course emphasizing the history of mathematics that took place in London and its surroundings. Topics will include itinerary, course content, and assessment. We will also discuss strategies for addressing such a course to non-majors and how to teach on a crowded street in the rain. (Received August 26, 2008)

1046-Z1-347 **Michael J. Caulfield*** (caulfiel001@gannon.edu), Department of Mathematics, Gannon University, 109 University Square, Erie, PA 16541. *Apportioning Seats in the U.S. House of Representatives.*

The U.S. Constitution mandates a decennial census. Results of the census are used to apportion seats in the U.S. House according to the populations of the states. But each state's share of the total U.S. population cannot equal its share of House seats since no partial seats are awarded. Various methods have been proposed, and used, throughout U.S. history to apportion these seats. We examine several of these methods by means of spreadsheet applications that are available for student use. (Received August 27, 2008)

1046-Z1-372 **Barbara Bennie*** (bennie.barb@uwlax.edu), 1725 State St, Mathematics Department, University of Wisconsin - La Crosse, La Crosse, WI 54601. *The Role of the Sampling Distribution in Student Learning of Inferential Statistics.*

Within an Elementary Statistics course, the sampling distribution is labeled by some as being a threshold concept. It is hypothesized that if students are able to develop a true understanding of the sampling distribution, then the conceptual understanding and practical application of related inferential methods will naturally follow. Alternatively, a lack of understanding of the sampling distribution is thought to lead to difficulty in learning the corresponding inferential methods. We examine student learning of the sampling distribution and its association with student performance on key procedural and conceptual elements from the course. Our aim is to assess to what extent the sampling distribution truly is a threshold concept. (Received August 28, 2008)

1046-Z1-375 **Kimberly Jordan Burch*** (kjburch@iup.edu), 210 South 10th St., Indiana, PA 15705, and **Yu-Ju Kuo**, 210 South 10th St., Indiana, PA 15705. *Traditional vs. Online Homework in College Algebra.*

A year long study was conducted in multiple sections of College Algebra by two professors using both traditional paper homework assignments and an online homework system. The online homework system was Pearson/Addison-Wesley's CourseCompass which was integrated with our textbook. This system allows the students multiple attempts at problems with extensive hints and examples while providing instant feedback for every problem. Data was collected from both groups including in-class exam scores, final exam scores, and homework averages. Of particular interest to the investigators was whether one method would help facilitate the understanding and retention of the material better than the other. We will present the analysis of our findings and the conclusions we have drawn. (Received August 28, 2008)

1046-Z1-386 **Chris Pavone**, **Sophy Huck**, **Megan K O'Connor** and **Carol A Wilson*** (carol@danwilson.com), 4160 Pine St., Rocklin, CA 95677, and **Elizabeth Zapata**. *An Examination of the Social Class Backgrounds of California's Mathematics Professors.*

As part of an NSF sponsored 6-week REU (Research Experience for Undergraduates) program, the Mathematics Education research group at California State University, Chico surveyed 957 University of California (UC) and California State University (CSU) tenured/tenure-track mathematics professors on their social class backgrounds. In this talk we will present our findings and discuss the implications for UC and CSU mathematics students' access to class-specific role models and how mathematics professors from lower social class backgrounds may help California's efforts to increase the number of students concentrating in mathematics. (Received August 29, 2008)

1046-Z1-388 **H A Dye*** (hadye@mckendree.edu), 701 College Road, McKendree University, Lebanon, IL 62254. *Geometry: the hardest course?* Preliminary report.

When we discuss courses that are difficult to teach, we often talk about analysis and abstract algebra. However, for me, the most difficult course to teach is geometry. My students include both elementary and secondary education majors. They represent a wide span in both abilities and educational backgrounds. In this talk, I present some of the strategies that I use in this course and the feedback that I have received from my students. (Received August 29, 2008)

1046-Z1-399 **Luz M. DeAlba*** (luz.dealba@DRAKE.EDU), Mathematics and Computer Science Department, Drake University, 2507 University Avenue, Des Moines, IA 50311. *Teaching Technology to First Year Students.* Preliminary report.

Many of us teach technology in our mathematics courses as it applies to the subject matter. With this paradigm, students learn to use one technology to solve very specific problems. It is typical in upper division courses, that when not introduced as part of the syllabus of a course, technology is either totally ignored by students, or used ineffectively. In both cases, the learning of higher mathematics is hindered.

In this talk, the author discusses the First Year Seminar "Technology for Mathematics" she has taught at Drake University. In this course, students are exposed to a variety of computer technologies (Excel, Geometer's Sketchpad, Mathematica) and mathematical problems (financial computations, growth models, numbers in different bases, graphing functions, basic geometry, linear transformations, probability, algebra). Students are also required to do a substantial amount of writing and to give a final oral presentation.

This First Year Seminar is designed to remove any fear of using technology, to give students the tools and confidence for them to continue to use technology in all their mathematics courses, to teach new mathematics topics to students, and to encourage students write and speak about mathematics. (Received August 31, 2008)

1046-Z1-403 **Lawrence A. D'Antonio*** (ldant@ramapo.edu), Ramapo College of New Jersey, School of Theoretical and Applied Science, Mahwah, NJ 07430. *Is Mathematics an Exact Science?*
This talk discusses an article of the same title written in 1948 by N. A. Court. He makes the argument that while mathematics is generally viewed as being synonymous with exactness, an historical perspective shows mathematics to be a very human enterprise, fraught with personal invective, disputes, errors, and uncertainty. A similar theme, namely the evolution of the concept of mathematical rigor, can be found in an article written by James Pierpont in 1928. This broadening of our idea of the mathematical enterprise was influenced by the work of Brouwer and Goedel. Nathan Altshiller Court was born in Warsaw in 1881 and emigrated to United States in 1911. He taught at the University of Oklahoma from 1917 to 1951 and wrote extensively on geometry, including well received texts on college and solid geometry. (Received August 31, 2008)

1046-Z1-406 **Hieu D Nguyen*** (nguyen@rowan.edu), Rowan University, Department of Mathematics, 201 Mullica Hill Rd, Glassboro, NJ 08028. *Discovering Bernoulli Number Identities via Euler-Maclaurin Summation.* Preliminary report.
In this talk I describe how interesting identities involving Bernoulli numbers can be generated from the Euler-Maclaurin Summation Formula. By applying the formula to Bernoulli polynomials and more generally to Appell sequences, we recover classical identities such as Euler's quadratic relation for Bernoulli numbers and discover new ones, including those involving hypergeometric (generalized) Bernoulli numbers. Students with only knowledge of first-year calculus can quickly set off on their own exploration for new identities. (Received September 01, 2008)

1046-Z1-444 **Katrina Palmer*** (palmerk@appstate.edu), 121 Bodenheimer Dr., Boone, NC 28608. *Teaching Differential Equations On-Line: The Challenges and Changes.*
In this talk I will share my experience teaching an on-line differential equations course. I will describe what makes a "good" on-line course, the challenges we faced, and changes I would make for the next time. (Received September 03, 2008)

1046-Z1-449 **John Hawkins** and **T. Bruce McLean*** (bmclean@georgiasouthern.edu), 19 Northlake Dr., Statesboro, GA 30458. *Using a Personal Response System.* Preliminary report.
Over the years, we have consistently used the latest technology in our classes. It has made us more organized and has increased the understanding of our students. Now we have combined our old presentations and drawings from the past and placed them in PowerPoint presentations with imbedded questions. These questions can be multiple choice or questions that have numerical answers. Our University has settled upon one company to provide a personal response system, eInstruction's Classroom Performance System (CPS). The students answer each question as it appears and we are able to evaluate our lectures in real time. Applets can still be activated from the presentations and MathType is used for all of the mathematical symbols needed in the presentation. We will show results from this past year's experimentations in beginning calculus classes, scientific and business/ (Received September 03, 2008)

1046-Z1-466 **Thomas Philip Wakefield*** (TomWakefield@gmail.com), Department of Mathematics, Slippery Rock University, Slippery Rock, PA 16057. *Verifying Huppert's Conjecture for* ${}^2G_2(q^2)$.
In the late 1990s, Bertram Huppert conjectured that if G is a finite group and H a finite nonabelian simple group such that the set of character degrees of G and H are the same, then $G \cong H \times A$, where A is an abelian group.

Huppert verified the conjecture for many nonabelian simple groups, including some of the simple groups of Lie type. His method of proof relies upon a five step procedure which ultimately requires properties of the character degrees and maximal subgroups of the simple group in question. We will examine the verification of Huppert's Conjecture for the family of simple groups ${}^2G_2(q^2)$, with $q^2 = 3^{2m+1}$, $m \geq 1$. (Received September 04, 2008)

1046-Z1-484 **Robert L. Davidson** (davidson@etsu.edu), Department Of Mathematics, Box 70663, Johnson City, TN 37614, and **Robert B. Gardner*** (gardnerr@etsu.edu), Department of Mathematics, Box 70663, Johnson City, TN 37614. *A Data Gathering Demo Using Three Stooges Films.*
A novel approach to data gathering based on the films of the Three Stooges is discussed in the setting of hypothesis testing. This demo has been used successfully in business, criminal justice, and math department classes.

A hypothesis concerning the levels of violence between various members of the Three Stooges is motivated by quotes from original members of the team (including audio files from interviews). Students then view parts of random samples from the populations of Stooge films and collect data relevant to the hypotheses under consideration. In the process, students experience the problems inherent in data collection in the "real world." Students then analyze collected data through various technologies (such as Excel, Minitab, or calculators with statistical capabilities).

Student opinion gathered through surveys supports the claim that this project stimulates student interest and attitude, relieves some math (or statistics) anxiety, and enhances conceptual understanding of the hypothesis testing procedure and of the data gathering experience. (Received September 04, 2008)

1046-Z1-493 **Elizabeth K. Mauch*** (emauch@bloomu.edu), 400 E. 2nd St., Bloomsburg, PA 17815. *Retention Programs for Women in STEM Fields with a Significant Mathematical Emphasis.* Preliminary report.

Currently, women represent more than half of all students entering undergraduate programs. However, less than half of all degrees in STEM (Science, Technology, Engineering and Mathematics)-related fields, especially those with a significant mathematical emphasis are awarded to women. In order to increase the number of women seeking to obtain STEM-related degrees, research needs to be conducted to determine which methods are most successful in retaining women majoring in STEM programs. Some models of recruitment and retention programs exist that appear to help increase the number of women obtaining STEM-related degrees, yet these programs are limited in number and are typically employed at large research institutions. The purpose of this presentation is to give a preliminary report on research findings. (Received September 04, 2008)

1046-Z1-508 **Ignatios Vakalis*** (ivakalis@calpoly.edu), CSC Department, CalPoly and State University, San Luis Obispo, CA 93407. *Models of Undergraduate Computational Science Curricula.*

Computational science and Engineering (CSE) is a rapidly growing interdisciplinary field that integrates computing, mathematical modeling, and visualization to solve complex problems in the physical, natural, behavioral and social sciences as well as engineering and finance. The SIAM Working Group on CSE Undergraduate was charged to report on the current status of CSE undergraduate education. The major objectives of the comprehensive report are to present the scope of CSE as an undergraduate discipline, to examine some of different models for CSE undergraduate programs, and to delineate the needs that undergraduate CSE preparation must address for a successful transition to industry or graduate programs. The talk with present the major findings of the SIAM report along with exemplary undergraduate CSE curricula. In addition, the presentation will include a summary of key components of an inter-institutional undergraduate program in computational science that implements a competency-based minor for majors in science, mathematics, and engineering. (Received September 05, 2008)

1046-Z1-529 **Arielle M Leitner*** (arielleleitner@sbcglobal.net), 1959 Rosecreek Ct., Chico, CA 95928. *Universal Cycles of Classes of Restricted Words.*

It is well known that Universal Cycles of k-letter words on an n-letter alphabet exist for all k and n. In this paper, we prove that Universal Cycles exist for restricted classes of words, including: non-bijections, equitable words (under suitable restrictions), ranked permutations, and "passwords". (Received September 10, 2008)

1046-Z1-536 **Jeff A Suzuki*** (jeff_suzuki@yahoo.com), Department of Mathematics, Brooklyn College, 2900 Bedford Ave., Brooklyn, NY 11210. *Are You In Or Out? Mathematical Lessons From Fashion Design.*

Shows like 'Project Runway' reflect a renewed interest in the fiber arts among the general population. Mathematics courses can capitalize on this interest through open-ended tasks that relate key problems in fashion design to key mathematical concepts. We will describe one such assignment, which incorporates a broad range of mathematical concepts from approximations and non-standard measurement to symmetry and tessellations. (Received September 07, 2008)

1046-Z1-561 **Kevin E. Charlwood*** (kevin.charlwood@washburn.edu), 7212 SW 25th Street, Topeka, KS 66614-4769. *Partial Fraction Decomposition Extensions.* Preliminary report.

We consider extensions on partial fraction decompositions beyond the coverage in standard Calculus texts. We consider a short cut for finding the unknown coefficients in a partial fraction decomposition, the use of complex numbers for irreducible quadratic factors, an extension to rational trigonometric functions, and an extension to decompositions for multivariate rational functions. (Received September 08, 2008)

1046-Z1-592 **Jacob Sloujitel*** (jsloujit@globe.edu), 291 Broadway, New York, NY 10007. *Pre/post tests for undergraduate mathematics.* Preliminary report.

This presentation describes the results of research on the student learning in discrete mathematics, pre-calculus, and calculus. Statistical comparison the results of the designed pre/post tests shows improvement of the scores and their dependence on student previous mathematics background. In spite of relatively large dispersion of data the pre/post test proved itself as a reliable tool for assessment of student learning. (Received September 08, 2008)

1046-Z1-601 **Anthony D. Berard, Jr.*** (anthonyberard@kings.edu), Department of Mathematics, King's College, North River Street, Wilkes-Barre, PA 18711. *A Research Project for a Beginning Mathematics Student.*

We will discuss a research project for first-year mathematics major. The project is to design a small axiom system. We will discuss the background needed by the student. Additionally, we will discuss independence and consistency of axiom systems and how the student may ensure that his/her axiom system satisfies those properties. Within the framework of this project the student will use direct and indirect arguments. In addition to learning how to prove certain statements the student will also learn how to show that it is impossible to prove other statements. (Received September 08, 2008)

1046-Z1-620 **Thomas Koshy*** (tkoshy@frc.mass.edu), 100 State Street, Framingham, MA 01701-9101. *Lobb's Generalization of Catalan's Parenthesization Problem.*

Recently, A. Lobb investigated the following generalization of Catalan's well-known parenthesization problem: Find the number $L_{n,m}$ of arrangements of $n+m$ positive ones and $n-m$ negative ones such that every partial sum is nonnegative, where $0 \leq m \leq n$. Using induction, Lobb showed that

$$L_{n,m} = \frac{2m+1}{n+m+1}\binom{2n}{n+m}$$

So $L_{n,0} = C_n$, the nth Catalan number. Interestingly, Lobb numbers $L_{n,m}$ can be extracted from Pascal's triangle by taking successive differences of adjacent elements to the left of and in the middle column in row $2n$.We will show that $L_{n,m}$ is odd for every m if and only if either $n = 0$ or n is a Mersenne number. Consequently, $L_{n,m}$ is odd for every m if and only if C_n is odd. In addition, we will extract a number of interesting properties involving Catalan and Lobb numbers; this includes the fact that every Catalan number C_{2n} can be expressed as the sum of $n+1$ squares. (Received September 09, 2008)

1046-Z1-703 **Janet A. White*** (jwhite@millersville.edu), Mathematics Department, PO Box 1002, Millersville University, Millersville, PA 17551-0302, and **Travis K. Miller** (tmiller1@millersville.edu), Mathematics Department, PO Box 1002, Millersville, PA 17551-0302. *Using Personal Response Systems (Clickers) for Pre-service Teacher Candidates in Elementary Content and Secondary Methods Courses.* Preliminary report.

The purpose of this session is to present the preliminary data on a research project involving the use of Personal Response Systems (PRS) in undergraduate mathematics classes. The first stage of the project involved collecting data from three sections of students in elementary mathematics content courses – two classes used the PRS on a regular basis in the course as an informal assessment of the comprehension of the reading assignments and a review of basic computational skills. The research project will seek to examine differences in the students regarding motivation and performance. The researchers are also looking for any correlations that might exist between the skill-oriented questions and student success in the course. The first phase also utilized PRS in the methods course for secondary mathematics majors to facilitate anonymity in motivating open-ended discussions. The session will also be used to share the plans for phase two of the implementation for the spring semester. (Received September 10, 2008)

1046-Z1-726 **Joel I. Kramer*** (jkramer@math.jhu.edu), Krieger 404, 3400 N Charles St, Baltimore, MD 21218. *Examples of Embedded Minimal Spheres without Area Bounds.*

The author proves that there is an open non empty set of metrics on any 3-manifold such that there exists a family of stably embedded minimal 2-spheres whose area is unbounded. This result generalizes the results of T. Colding and W. Minicozzi who have shown an analogous result for the torus and B. Dean who showed the positive genus case. (Received September 10, 2008)

1046-Z1-741 **Laura J Schmidt*** (schmidtlaur@uwstout.edu), University of Wisconsin-Stout, 237 Harvey Hall, Menomonie, WI 54751, and **Eileen M Zito** (zitoe@uwstout.edu), University of Wisconsin-Stout, 237 Harvey Hall, Menomonie, WI 54751. *Engagement Across the Disciplines.* Preliminary report.

What fosters engagement? Our project explored engagement strategies to increase student learning through self-reflection. The strategies we implemented weekly were think/write/pair/share, muddiest point papers, and critical incidence questionnaires. Our goal was to help students' reflect on their learning on a deeper level. Literature exists that indicates that engagement is helpful to increase learning, but those studies usually focused on only one field. Our study investigated engagement by testing whether six teachers employing the same strategies in four disciplines increased learning within those same disciplines. During our presentation we will provide an overview of the project and the results across the disciplines. (Received September 10, 2008)

1046-Z1-772 **Laura J Schmidt*** (schmidtlaur@uwstout.edu), University of Wisconsin-Stout, 237 Harvey Hall, Menomonie, WI 54751. *Teacher versus Student Motivation: Who wins the game?* Preliminary report.

What characteristics define the motivated student in a General Education Mathematics course? What do students name as the teaching techniques and activities that motivate them? How do we motivate our students when we teach a General Education required course? These are the questions that made up the focus of my Wisconsin Teaching Fellow Project this year. During the Fall '08 semester, I surveyed both students and instructors (separately) to determine the characteristics they think most motivate students. The students were asked which activities in the class motivated them the most to work and to succeed. During the Spring '09 semester, I will implement the activities and methods identified through those surveys to foster increases in motivation. My presentation will focus on the results of the surveys - comparing the students' and instructors' responses and discussing details of implementation for the Spring term. (Received September 11, 2008)

1046-Z1-776 **Michael J. Adams*** (mjadams@truman.edu), Dept. of Mathematics and Computer Science, Truman State University, Kirksville, MO 63501, and **Jonathan D. Vollmer**. *Loop Decompositions of Circulations in Strongly Connected Digraphs.* Preliminary report.

We address the problem of partitioning a nonnegative circulation in a strongly connected digraph over a set of elementary directed cycles: in mathematical ecology, such a partition is called a loop decomposition. We show that the set of loop decompositions can be put into one-to-one correspondence with the set of points belonging to the feasible set of a linear programming problem that allows us to minimize linear functions of the flows in any given set of directed cycles. We also describe a recursive algorithm developed for listing all directed cycles in a digraph. These results generalize the method of demographic loop analysis used in mathematical ecology. (Received September 15, 2008)

1046-Z1-784 **Jason J Molitierno*** (molitiernoj@sacredheart.edu), Sacred Heart University, Department of Mathematics, 5151 Park Avenue, Fairfield, CT 06825-1000. *Enumerating Graphs to Conveniently Produce Adjacency Matrices Using Maple or Mathematica.*

When working in graph theory, it is often useful to represent a graph using either the Adjacency Matrix or the Laplacian matrix. However, if the graph is large, it can be cumbersome to type such a large corresponding matrix into mathematical software such as Maple or Mathematica. In this talk, we investigate convenient ways that we can assign a graph a single number. Once the number for a graph is determined, I then show how we can construct a program so that the Adjacency matrix or Laplacian matrix for the graph can be instantly produced simply by typing a single number! (Received September 11, 2008)

1046-Z1-806 **Jenna P Carpenter*** (jenna@coes.latech.edu), PO Box 10348, Ruston, LA 71272. *Strategies for Effective Use of Online Homework in Calculus.*

Homework is a standard part of most calculus courses. Moving homework out of the textbook and into an online environment affords the opportunity to improve individual accountability and mastery of course content, as well as the degree of interaction between faculty and student. Here we will examine strategies for effectively using online homework in a calculus course to achieve each of these goals, supported by assessment data on student use. (Received September 11, 2008)

1046-Z1-810 **Marja-Liisa Hassi*** (hassi@colorado.edu), Ethnography & Evaluation Research, University of Colorado, 580 UCB, Boulder, CO 80309-0580, and **Sandra Laursen** (sandra.laursen@colorado.edu), Ethnography & Evaluation Research, University of Colorado, 580 UCB, Boulder, CO 80309-0580. *Studying Affect in Undergraduate Mathematics: Efforts to Clarify Students' Experiences of Learning Mathematics.* Preliminary report.

Constructivism represents a general paradigm largely accepted in current mathematics curricula throughout the world. Another widely emphasized perspective considers mathematics as social constructions taking place in social contexts. Metacognition has been stressed as an important determinant of successful mathematical problem solving that differs from pure cognition but is closely related to affect. Increased application of these aspects in mathematics education research has offered more opportunities to study the role of affective issues in students' mathematical thinking and learning. The ways that students view and experience mathematics learning situations will determine their goals and modes of understanding, responding and behavior in doing and learning mathematics. We will consider in this presentation some important affective constructs with respect to students' mathematical beliefs and experiences. Connections will be developed between theory and research practice by describing both quantitative and qualitative measurements in use in an evaluation research project focusing on inquiry-based learning in undergraduate mathematics. Examples will be offered of the quality and variation of undergraduate students' views and experiences of learning mathematics. (Received September 11, 2008)

1046-Z1-817 **Betsy Darken*** (betsy-darken@utc.edu), Mathematics Department # 6956, University of Tennessee at Chattanooga, 615 McCallie Ave., Chattanooga, TN 37403. *Facing Up to the Realities of Quantitative Illiteracy: Do You Know What Your Students Do NOT Know about "Basic" Mathematics?*

Next time you encounter some math students, consider asking them the following questions: (1) What is the fraction form of 33 and a third percent? (2) How much will you save if you buy an item at a 25 percent off sale and its sale price is $360? (3) Write 0.0004 as a simplified fraction. (4) Your swimming pool is 20 feet by 30 feet by 4 feet 6 inches and you are filling it with water coming in at a rate of 4.5 gallons per second. Find out how long it will take to fill an empty pool; it may be helpful to know that 1 gallon contains 231 cubic inches. (5) What is 4 divided by 0 and why do you think so? In this talk I will present the results of research studies on questions of this sort, including results from the National Assessment of Educational Progress, studies of college students, and surveys of American adults. These data indicate that there is a shocking lack of understanding of certain areas of mathematics that college math professors tend to think of as "middle school mathematics." I will present data indicating that even calculus students have weaknesses in these areas. I will also describe an endeavor to deal with this problem head-on, along with the trials, tribulations, and thrills attendant thereto. (Received September 11, 2008)

1046-Z1-844 **Sharon S Emerson-Stonnell*** (emersonstonnellss@longwood.edu), Mathematics Department, Longwood University, 333 Ruffner, Farmville, VA 23909, and **Robert D Markey** (rdm168@longwood.edu), 107D Lancer Cir, Farmville, VA 23901. *Coordinating Tutoring with the Calculus I Classroom.* Preliminary report.

This year the mathematics department at Longwood University created more structured tutoring sessions in Pre-calculus and Calculus I to try to increase student success in the classes. The Calculus I instructor and tutor will present the results of this collaboration. The Calculus I instructor is responsible for overseeing the tutoring sessions for Calculus I. The tutor, a senior mathematics education major, holds a two one-hour tutoring session each week in the evenings. The first 30 minutes of each session is the lesson plan created specifically for student needs and the second thirty minutes is a general question and answer session. The tutor attends the math class once a week to observe the teaching methods as well as content taught in the class. After grading student homework and labs, the instructor provides the tutor information about the difficulties the class is having along with recommendations for tutoring lessons. The tutor then develops a 30 minute lesson around the topic and brings it by the instructor's office for approval and revision before each tutoring session. Preliminary report. (Received September 12, 2008)

1046-Z1-870 **Colin L Starr*** (cstarr@willamette.edu), Mathematics Department, Willamette University, 900 State St, Salem, OR 97301, and **Inga Johnson**. *The WiVaM Consortium REU-RET.* Preliminary report.

The Willamette Valley Mathematics Consortium is unique among REU-RETs in that the REU-RET site grant actually funds four separate schools in Oregon's Willamette Valley into a consortium of research teams. We will discuss the principles of the consortium, the logistics, and the outcomes thus far. (Received September 12, 2008)

1046-Z1-875 **José María Menéndez*** (jmenendez@math.arizona.edu). *Mathematics From Work and Home: Lessons Learned.*

In this presentation we report on our findings working with adults participating in mathematics workshops. We examine how the characteristics of nonformal settings (systematic, not for accreditation and promotion, adapted to the unique situation of the participants, voluntary attendance, and relatively flexible structure) impact adult mathematics education. Our data come from workshops with parents of Latino students in elementary and middle schools that we analyze from a cognitive-affective perspective. We find that adults become more engaged in exploring, learning, and teaching mathematics when their experiences are incorporated in the learning process and when the mathematical content is presented in contextualized situations. We outline our conceptual understanding of nonformal education and show how this particular nature of the workshops creates a favorable environment for learning mathematics in a participatory and reflexive way. (Received September 12, 2008)

1046-Z1-886 **Jeremy D Hauze*** (jeremyhauze@kings.edu), 323 South Kennedy Drive, McAdoo, PA 18237. *Examining the box topology on the Cartesian product of connected spaces.* Preliminary report.

The product space of a family of topological spaces is the Cartesian product of these spaces, with a specific product topology. The basis of the product topology for $X = \Pi_{i \in \mathbb{I}} X_i$, where $\mathbb{I}$ is an indexing set, is made up of sets of the form $\Pi_{i \in \mathbb{I}} U_i$ with U_i an open subset of X_i and $U_i = X_i$ for all but a finite number of indices.

One result of interest in the product topology is that if each component space X_i is connected, the product space on $X = \Pi_{i \in \mathbb{I}} X_i$ is connected. However, this result holds specifically in the product topology. Another topology on the Cartesian product of sets, the box topology, is identical to the product topology on the same set, save without the restriction that $U_i = X_i$ for all but a finite number of indices. It is our goal to examine the box topology to see whether a space with the box topology is connected under the circumstance that each component space is in fact connected. We will accomplish this by considering the set $\Pi_{i \in \mathbb{N}} \mathbb{R}$, where each component has a usual topology on $(\mathbb{R}, \mathcal{U})$. As $(\mathbb{R}, \mathcal{U})$ is connected, this set is connected under the product topology. We will examine whether this set is connected under the box topology. (Received September 12, 2008)

1046-Z1-904 **Ralph P. Grimaldi*** (ralph.grimaldi@rose-hulman.edu), Department of Mathematics CM 132, Rose-Hulman Institute of Technology, 5500 Wabash Avenue, Terre Haute, IN 47803. *Tiings, Compositions, and Generalizations.*

For n > 0, consider tiling a 1xn chessboard with 1x1 squares and 1x2 rectangles. The squares come in w colors and the rectangles in t colors. Among other considerations, one can ask for (1) the number of possible tilings; (2) the number of times a particular type of tile is used; and, (3) the total number of tiles used. This situation can be rephrased in terms of compositions using only 1's and 2's as summmands, where there are w kinds of 1's and t kinds of 2's. Now, for example, we can ask for the numbers of levels, rises, and descents that occur among these compositions. Finally, a relationship can be derived involving a sum of products of summands in the compositions of n (taken over all compositions of n) and the number of tilings of the 1x(2n-1) chessboard. (Received September 12, 2008)

1046-Z1-909 **David T. Atkinson*** (datkinsn@olivet.edu), Department of Mathematics, Olivet Nazarene University, Bourbonnais, IL 60914. *Chances of a Cruise Ship Birthday Match.*

What are the chances that during a cruise of k days there will be one or more matching birthdays among the n passengers? A solution of this problem, accesible to undergraduate mathematics majors, will be presented. Also for selected values of k, we will note the minimum value of n for which the probability of a match is at least 50%. (Received September 12, 2008)

1046-Z1-918 **Dale K Hathaway*** (hathaway@olivet.edu), One University Avenue, Department of Mathematics, Olivet Nazarene University, Bourbonnais, IL 60914. *The Continuous Birthday Problem.*

The classic birthday problem uses calendar days as the time period for a match. What if instead of using calendar days any 24 hour period of time is used as the time frame? Two or more birthdays within the 24 hour period would be considered a match. A person born at 11:55 p.m. on January 1 would be within 24 hours of a person born at 3:38 a.m. on January 2, even though they have separate calendar day birthdays. This generalization of the birthday problem can be solved by taking an approach similar to the Calculus approach of using discrete rectangles to approximate the area under a continuous function. A continuous birthday match will be shown to be more likely than that of a classic birthday match. (Received September 12, 2008)

1046-Z1-923 **Nicole Stawasz*** (nicolestawasz@kings.edu), King's College, 133 N. River St., Wilkes-Barre, PA 18711. *Mathematical Models for Call Options on Stocks.*

A call option gives you the option to buy the stock for a fixed price at a given future date. We want to find a mathematical model so that we can calculate the value of the call option at any time step from now to the maturity. A CDF gives us more information about the call option, so we find a sequence of CDF's based on the time steps and use characteristics equations and Levy's Continuity Theorem to find that these CDF's converge to a CDF after some rescaling. Finally, we use this to derive an equation for the price of the call option today as the number of time steps converges to infinity. (Received September 12, 2008)

1046-Z1-924 **Rebecca S Patterson** (becky.patterson@louisville.edu) and **Larry Wayne Lewis*** (llewis@spalding.edu). *Testing the effects of predictors data generated by non-identity link functions of the singe-index model: a Monte Carlo appraoch.*

Regression analysis is a statistical procedure that identifies the relationship between two or more quantitative variables; namely, a response (dependent) variable whose value is to be predicted and one or more explanatory (predictor) variables, about which information is available. The critical step in regression analysis is the construction of the explanatory model. Single-index models are a generalized regression models by having unknown link functions. A simple methodology to test effects of predictors in single-index models is presented under mild conditions. Since the proposed method does not require preliminary specification of link functions, it can be considered as model-free predictor tests. Simulations were tested to validate the proposed method. The method was applied to predict the gene transcription rates by histone acetylation levels in the presence of transcription factor binding motifs in Saccharomyces cerevisia (Yuan et al., 2006). (Received September 12, 2008)

1046-Z1-937 **Scott F. Beaver*** (beavers@wou.edu), Mathematics Department, Western Oregon University, 345 N. Monmouth Ave., Monmouth, OR 97361. *The Natural Role of Lower-Division Sequences and Series as a Pre-Bridge Course.*

Sequences and Series can be structured to provide students with an opportunity to build their proofs skills prior to, or concurrently with, a bridge course while sacrificing little or no content. The guiding principle is that *students actually prove statements about particular sequences or series throughout the course.* Though they do not prove broadly applicable theorems, they do prove that specific sequences or series converge or diverge, whichever applies. This provides a wonderful setting in which to hone students' application of logical principles to mathematics, without the additional encumbrance of abstraction early in their undergraduate years. I'll discuss my emphasis on logical reasoning and the worksheet-based guided-inquiry course structure, and present the additional theorems and definitions provided to the students to ensure that they have all the tools necessary to rigorously solve the problems in the course. (Received September 12, 2008)

1046-Z1-978 **Michael D. Barrus*** (mbarrus2@illinois.edu), Department of Mathematics, University of Illinois, Urbana, IL 61801, and **Douglas B. West** (west@math.uiuc.edu), Department of Mathematics, University of Illinois, Urbana, IL 61801. *Reconstructing graphs given only a few marked cards.*

The famous Graph Reconstruction Conjecture states that every graph on n vertices can be uniquely determined given its deck of cards, i.e., the collection of induced subgraphs on $n-1$ vertices. We examine a related problem posed by S. Ramachandran in which only a few cards are given, along with the degrees of the deleted vertices. We show that for caterpillars (connected graphs where deleting all the vertices of degree 1 leaves a path) we can reconstruct the graph given only one or two of these cards, with one exception. (Received September 13, 2008)

1046-Z1-1004 **Zengxiang Tong*** (ztong@otterbein.edu), Mathematical Sciences Department, Otterbein College, Westerville, OH 43081. *Extended Newton-Leibnitz Theorem.*

The Newton-Leibniz Theorem is called the Fundamental Theorem of Calculus and is contained in every calculus book. This paper proves a generalization of the Newton-Leibniz and suggests all authors and professors enclude this extended Newton-Leibniz Theorem in their calculus books and lectures. This paper will also present several interesting examples to show the need and power, mathematically and pedagogically, of this theorem. (Received September 13, 2008)

1046-Z1-1063 **Stan VerNooy*** (stan.vernooy.ccsn@gmail.com), College of Southern Nevada, 700 College Drive, H10B, Henderson, NV 89002. *What if Your PreCalculus Student Asks a Good Question?*

I have had three PreCalculus students ask thought-provoking questions in the last few years: once when I (and every other PreCalculus teacher and textbook-writer) was caught in a lie concerning partial fractions; once when an architecture major wanted to use vectors to determine the proper angles in an architectural drawing; and once when a student was interested in complex solutions to real inequalities. It turns out that those three questions produce excellent examples of three very different categories of responses. (Received September 14, 2008)

1046-Z1-1068 **Joseph B. Liddle*** (jbliddle@uas.alaska.edu), 609 Sawmill Creek Rd., Sitka, AK 99835, and **Michael Musyl** (Michael.Musyl@noaa.gov), University of Hawaii, Pelagic Fisheries Research Programme, Kewalo Research Facility/NOAA, Honolulu, HI 96814. *Optimizing data returned by pop up satellite tags.* Preliminary report.

Pop-up satellite archival tags (PSATs) are an invaluable sampling tool used for recording ambient pressure (depth), temperature and light irradiance (from which daily "geolocations" can be calculated) on pelagic fishes, sharks and turtles. Before deploying the PSAT, the researcher must first choose the pop-up period and the interval between data points. If the pop-up period is too long, the PSAT will lack sufficient battery power to communicate the data it has recorded to the geosynchronous system of polar orbiting ARGOS satellites. If it is too short, there will be little data returned. The interval between points influences data resolution. There is also a risk of total system failure with no data return. For optimizing the sampling design, it is desirable to find what pop-up period returns the greatest amount of data. We therefore derived a model describing the amount of data returned from PSATs dependant on the pop-up period and interval between data points, which yielded an estimator of the optimal pop-up period. We evaluate the sensitivity and variability of the optimum estimates with bootstrap analysis. (Received September 16, 2008)

1046-Z1-1070 **Joseph B. Liddle** (jbliddle@uas.alaska.edu), 609 Sawmill Creek rd., Sitka, AK 99835, **Colleen Ianuzzi*** (colleen.ianuzzi@uas.alaska.edu), University of Alaska Southeast, 2600 Seventh Avenue, Ketchikan, AK 99901, and **Chris Hay-Jahans** (jfcnh@uas.alaska.edu), University of Alaska Southeast, 11120 Glacier Hwy, Juneau, AK 99801. *Project Based Distance Delivered Elementary Statistics.* Preliminary report.

Students in traditional elementary statistics courses often struggle with both computations and concepts. Such difficulties are magnified in most distance delivered courses. UAS distance students are scattered from Nome in the north to Ketchikan in the south, a range of about 1200 miles. Teaching statistics to students located at remote regions has posed many challenges. UAS distance delivery statistics instructors have overcome many of these challenges through the use of real world data analysis projects, successfully conveying computational methods and conceptual ideas to distance students. > This talk begins with a review of recommendations from the literature, primarily those provided in the GAISE College Report published by the American Statistical Society (Aliaga et. al., 2005), followed by examples of data analysis projects completed by distance students. Finally, a discussion on observed obstacles faced by students, and a list of tested strategies for implementing and assessing student projects via distance delivery methods are presented. (Received September 16, 2008)

1046-Z1-1072 **David W Shoenthal*** (shoenthaldw@longwood.edu), Dept. of Mathematics and Computer Science, 201 High Street, Farmville, VA 23909. *A Geometric Complexity Problem in a Length Space.*

I discuss a relationship between the complexity of a shortest path problem in three dimensions and a low dimensional length space. The shortest path problem under consideration is in some sense a linearization of a two dimensional shortest path problem. With the aid of length space geometry, I conclude that a version of the knapsack problem is polynomially reducible to the nonholonomic shortest path problem considered. (Received September 14, 2008)

1046-Z1-1083 **Timothy A. Redl*** (REDLT@UHD.EDU), University of Houston Downtown, Dept. of Computer & Mathematical Sciences, One Main Street, Suite S705, Houston, TX 77002. *Development and Analysis of a New Course in Computational Mathematics with MATLAB at the University of Houston-Downtown.*

Plans are in motion for the University of Houston-Downtown's Computer and Mathematical Sciences Dept. (CMS) to establish a computational science program consistent with that of Rice University's Computational and Applied Mathematics Dept. (CAAM). As a means of achieving this dream, the author, a current faculty member in CMS at UH-Downtown and a 2004 Ph.D. graduate of CAAM at Rice, has developed a new course, MATH 2301: Introduction to Computational Mathematics, recently added as a degree requirement for all UH-Downtown applied mathematics majors. Taught since Spring 2008, MATH 2301 is a problem-solving applied mathematics and programming course involving modeling, simulation, and visualization using a computer algebra system. We document the history of the development of this course, along with an analysis of its first two semesters of existence (Spring and Fall 2008 with MATLAB), in terms of course content, student success, and its goal of being a practical introduction to computational science that will benefit students at UH-Downtown in their future mathematics courses and undergraduate research projects.

Key Words: computational mathematics, MATLAB (Received September 14, 2008)

1046-Z1-1101 **Shlomo - Libeskind*** (shlomo@uoregon.edu), Mathematics Department, University of Oregon, Eugene, OR 97403. *Which solution or proof is better and why?*

We will bring examples from college algebra and geometry to show how different solutions to the same problem enhance learning, and discuss criteria for a better solution. (Received September 14, 2008)

1046-Z1-1110 **Mohamed Allali*** (allali@chapman.edu), One University Drive, Chapman University, Mathematics and Computer Science Department, Orange, CA 92866. *Digital Signal Processing in the Service of Mathematics Courses.*

In this talk, I will show through many practical and easy to implement examples how basic digital signal processing can be incorporated into many mathematics courses such as discrete mathematics and linear algebra. This approach makes the courses more visual and interesting for instructors and students. (Received September 14, 2008)

1046-Z1-1114 **Elliott S. Elliott*** (selliott@utm.edu), Department of Mathematics and Statistics, 424 Humanities Building, 209 Hurt Street, Martin, TN 38238-0002. *10 Questions about Numbers: A College Algebra Writing Assignment.* Preliminary report.

This paper examines the successes and failures of a writing assignment required in a college algebra course. Students picked a number from a list including, among others, the digits 0 through 9, e, $\aleph_0$, and $\sqrt{2}$. They wrote a paper answering three questions of their choice from a list of ten, such as "How old is this number?" and "What are some examples of this number in art?" The students then shared their papers through oral presentations in class.

The goals of the assignment were to increase interest in mathematics, provide cultural content within the algebra course, and to have students discover some of the beauty of mathematics. To see how well these goals were met, we will look at some of the answers the students gave, student feedback about the assignment, and the instructor's thoughts about the assignment. (Received September 14, 2008)

1046-Z1-1116 **Daniel Joseph Galiffa*** (Da786917@pegasus.cc.ucf.edu). *The Sheffer B-Type 1 Orthogonal Polynomial Sequences.* Preliminary report.

In 1939, I.M. Sheffer proved that every polynomial sequence belongs to one and only one *type*. Sheffer extensively developed properties of the *B-Type 0* polynomial sequences and determined which sets are also orthogonal. He subsequently generalized his classification method to the case of arbitrary *B-Type k* by constructing the generalized generating function $A(t)\exp\left[xH_1(t) + \cdots + x^{k+1}H_k(t)\right] = \sum_{n=0}^{\infty} P_n(x)t^n$, with $H_i(t) = h_{i,i}t^i + h_{i,i+1}t^{i+1} + \cdots$, $h_{1,1} \neq 0$. Although extensive research has been done on characterizing polynomial sequences, no analysis has yet been completed on sets that are type one or higher ($k \geq 1$). We present a preliminary analysis of a special case of the *B-Type 1* ($k = 1$) class, which is an extension of the *B-Type 0* class, in order to determine which sets, if any, are also orthogonal. In this work the utilization of computer algebra packages is indispensable, as computational difficulties arise in the *B-Type 1* class that are unlike those in the *B-Type 0* class. (Received September 14, 2008)

1046-Z1-1119 **Anand L. Pardhanani*** (pardhan@earlham.edu), Department of Mathematics, Earlham College, Richmond, IN 47374. *Teaching introductory differential equations courses through real-life case studies.*

Rapid advances in computational technology together with shifting teaching paradigms have inspired several efforts to reform the content and strategies used in teaching ordinary differential equations (ODE) courses. Some well-known examples include the Boston University ODE Project, the Connected Curriculum Project (Montana State University), the C*ODE*E Project (Harvey Mudd College), and the IDEA project (Washington State University).

A key focus of reform efforts has been to make introductory ODE courses more broadly relevant and connected to current and emerging application areas. Technology has made it possible to design an ODE course that covers the best classical methods and mathematical theory, together with elements of modeling, computer-based solution methods and related explorations.

In this presentation I will discuss my approach to reshaping a classical introductory ODE course at a liberal arts college. I will mainly focus on a series of mini projects that were designed based on real-life case studies. Collectively these case studies involved applying classical ODE techniques as well as aspects of modeling and computer-based methods. I will discuss where to find sources for case studies, and how to adapt them to topics of interest in standard ODE courses. (Received September 14, 2008)

1046-Z1-1138 **Sandra J Schroeder*** (s-schroeder@onu.edu), Ohio Northern University, Mathematics Department, 525 S. Main Street, Ada, OH 45810. *Why is One Usually First?* Preliminary report.

If we disregard numbers that are purposefully distributed, can we find a pattern in the distribution of first digits? Surprisingly, yes. I'll share a formula that gives amazingly close results to our data. This is an easy and interesting topic that allows for simple data collection for analysis and comparison. (Received September 14, 2008)

1046-Z1-1165 **Mark H. Inlow*** (inlow@rose-hulman.edu), CM 143, Rose-Hulman Institute of Technology, 5500 Wabash Avenue, Terre Haute, IN 47803. *Elementary Central Limit Theorems Via Mathematical Induction.*

In this talk we present two new central limit theorems. The first, simpler proof is for the special case in which the sample size n equals 2^l, $l = 1, 2, \ldots$. The second is a generalization of the first to arbitrary n. Both proofs use mathematical induction but are otherwise elementary; they avoid moment-generating functions and only require that students understand moment calculations involving two independent random variables. In particular, the simpler "power of two" proof is suitable for use in post-calculus introductory statistics courses and other undergraduate courses in which one would like to prove a central limit theorem prior to or without covering moment-generating functions. (Received September 15, 2008)

1046-Z1-1174 **Clyde L. Greeno*** (greeno@mathematicsinstitute.org), MALEI Mathematics Institute, P.O. Box 54845, Tulsa, OK 74155-0854. *The Promises of Clinical Instructological Research.*

This presentation airs a research mode that yields many profound findings about how to improve curricula and instructional practices. A few illustrative findings are sketched – some of which serve to prevent or reduce MLD (Mathematics-Learning Distress: apprehension, anxiety, depression, phobia, etc.).

As an extreme form of case-study research, clinical research is overlaid onto an ongoing program of clinical instructional services – for students who need deeper conceptual understanding and stronger personal mathematical powers than they can acquire through normal instructional practices that follow traditional curricula.

In the MALEI Mathematical Learning Clinic, such research is carried to the next level – instructological research is aimed at learning how the prevailing technologies and practices of curricular instruction can be improved. The student is regarded as being an evolving, internal personal mathematical theory (albeit mostly informal, intuitive, or even sub-conscious). Following the mode of clinical psychology, the instructional guidance is maximally eductive – telling the students no mathematics that they can be led to construct for themselves. The instructological studies are about what fails and what works, how, and why. (Received September 15, 2008)

1046-Z1-1187 **Bernardo Rivera Marquez*** (bernard@adnu.edu.ph), Department of Computer Science, Ateneo de Naga University, 4400 Naga City, Philippines. *Problems in Combining Rational Expressions and Factorization of a Special Kind of Quadratic Trinomial.*

One of the skills that any student taking algebra has to learn is how to combine rational expressions. Developing the skill requires that the student already knows how to get the least common denominator, how to add and multiply polynomials, and how to factor polynomials to see whether the resulting rational expression can be reduced to lowest terms. To help the student develop the skill, the math teacher may come up with sets of exercises to attain the objective. S/he may just randomly pick any two rational expressions that the student has to combine. However, if the teacher wishes the exercises to be more engaging, the rational expressions have to be carefully chosen so that the solutions would reinforce previously learned skills. This paper aims to show how the formulation of certain problems on the addition or subtraction of rational expressions leads to the question of when is the sum of factorable quadratic trinomials is still factorable. The search for such quadratic trinomials will then be described. This will somehow illustrate how a basic topic in algebra can lead to some questions in number theory. (Received September 16, 2008)

1046-Z1-1218 **William Goldbloom Bloch*** (bbloch@wheatoncollege.edu), Department of Mathematics, Wheaton College, Norton, MA 02492. *Discontinuous open maps from $\mathbb{R}^n$ onto $\mathbb{R}^n$.*

Let X and Y be topological spaces. Recall that a map $f : X \to Y$ is an open map if for all open sets $A \subset X$, it is the case that $f(A)$ is open in Y. We provide two interesting examples. The first is an independent rediscovery of a discontinuous open map from $\mathbb{R}$ onto $\mathbb{R}$. The second is a new simple example of a discontinuous open map from $\mathbb{R}^2$ onto $\mathbb{R}^2$. We'll also state—and, time permitting, sketch the proof—of a minor proposition showing that a bijective open map from $\mathbb{R}^n$ onto $\mathbb{R}^n$ is continuous. (Received September 15, 2008)

1046-Z1-1237 **David K Hammond*** (david.hammond@epfl.ch), EPFL - STI - IEL - LTS2, Station 11, 1004 Lausanne, Switzerland, and **Pierre Vandergheynst** (pierre.vandergheynst@epfl.ch) and **Remi Gribonval** (remi.gribonval@inria.fr). *Wavelets on Graphs via Spectral Graph Theory.*

We propose a novel method for constructing wavelet transforms of functions defined on the vertices of an arbitrary finite graph. In the traditional continuous setting, wavelets are generated by translating and scaling a small number of "mother" waveforms. One challenge for extending this theory to graphs is the difficulty of defining appropriate translations and scalings for functions on an arbitrary irregular graph. In our approach we define a notion of scaling using the graph analogue of the Fourier domain, namely the space of eigenfunctions forming the spectral decomposition of the discrete graph Laplacian L. Given an arbitrary measurable function g, the spectral decomposition allows one to define the operator $T_g = g(L)$. Scaling by t may then be defined by $T_g^t = g(tL)$. Our graph wavelets $W_{t,j}$ at scale t and j are produced by localizing this operator to the vertex j by $W_{t,j} = g(tL)\delta_j$, where δ_j is the indicator function for the vertex j. The transform coefficients are then given by taking inner products with these wavelet waveforms. We show that, subject to an admissibility condition on g, this procedure defines an invertible transform. In addition, we explore the localization properties of the wavelets in the limit of fine scales. (Received September 15, 2008)

1046-Z1-1263 **Charlie Smith*** (charlie.smith@park.edu), Park University, 8700 NW River Park Drive, Mathematics Department #30, Parkville, MO 64152. *Duplication, Trisection, and Quadrature by Cheating.*

Over the centuries, there have been several successful attempts to Double the Cube, Trisect an Angle, and Square the Circle without the exclusive use of Euclidean tools. This presentation will examine the history as well as the mathematical details of selected constructions. Time permitting, one example of each classic construction will be analyzed. (Received September 15, 2008)

1046-Z1-1267 **Katherine Safford-Ramus*** (ksafford@spc.edu), Mathematics Department, 2641 Kennedy Boulevard, Jersey City, NJ 07306. *A Summary of Research about Perspectives on Knowledge with Implications for Undergraduate Mathematics Education.*

Research about perspectives on knowledge began more than fifty years ago with Perry's studies of Harvard undergraduates (Perry, 1970). In the intervening years, others have ventured beyond the white, male undergraduate subjects of Perry's work to explore the applicability of his findings to undergraduate women (Magolda, 1992 and 2001), cross-cultural women (Belenky, Clinchy, Goldberger, and Tarule, 1997), and men and women across class lines (Helsing, Drago-Severson, Kegan, Portnow, Popp, and Broderick, 2001; Kegan (1982 and 1994). The perspectives of teachers towards knowledge were examined by Pratt (Pratt, 1998).

There have, however, been no large-scale studies that explore the impact on and impasse that perspective poses for the undergraduate student of mathematics. Furthermore, there is little discussion of perspective in the literature on affective factors in mathematics education. This presentation proposes to summarize and fuse the findings of the major studies about perspectives on knowledge. The author will discuss the implications of the findings for undergraduate mathematics instructors. (Received September 15, 2008)

1046-Z1-1279 **Mahmoud Yousef*** (yousef@ucmo.edu), Dept. of Math. & Comp. Sci., University of Central Missouri, Warrensburg, MO 64093, **Shing S So** (so@ucmo.edu), Dept. of Math. & Comp. Sci., University of Central Missouri, Warrensburg, MO 64093, and **David Ewing** (ewing@ucmo.edu), Dept. of Math. & Comp. Sci., University of Central Missouri, Warrensburg, MO 64093. *The Modified Moore Method versus the Traditional One: A Case Study.* Preliminary report.

There are different schools of thought when it comes to delivering classroom instruction, those who support and use the traditional way of teaching, those who prefer the Modified Moore Method (MMM), and others who prefer a different style of teaching. In this paper, the MMM and the traditional way of instruction will be discussed and compared based on a case study. (Received September 15, 2008)

1046-Z1-1300 **Paul S. Rossi*** (prossi@cse.edu), College of Saint Elizabeth, 2 Convent Road, Morristown, NJ 07960. *Making Effective Use of the Uniform Distribution in an Introductory Probability Theory Course.*

The uniform distribution is, by far, the most basic and straightforward continuous distribution presented in an introductory probability theory course. Although one can easily use the integral (single or double) of a uniform probability density function (pdf) to evaluate probabilities, the properties of the uniform distribution permit the student to calculate these probabilities without the use of calculus. It is these same properties that allow an instructor to use the uniform distribution to reveal to students much about the nature of a non-uniform pdf. In this paper we present some ideas on how to effectively use the uniform distribution in a calculus-based probability theory course. These ideas include: (a) evaluating one-dimensional, and two-dimensional, probabilities, (b) evaluating conditional probabilities, (c) recognizing when a general pdf is increasing, or decreasing, and (d) placing upper, and lower, bounds on a probability (including expected values). Each of these ideas will be illustrated with a specific example. (Received September 15, 2008)

1046-Z1-1324 **Pascal Bedrossian** (pbedross@cbu.edu), 650 East Parkway South, Mempis, TN 38104, and **Cathy W Carter*** (ccarter@cbu.edu), 650 East Parkway South, Memphis, TN 38104. *Mathematics Immersion for Freshman Engineers (MIFE).*

In the past, some engineering departments have been quite content to have math departments filter students for them. Now that enrollments have declined nationwide, there is a need for mathematics to become more of a pump. Our answer at Christian Brothers University is immersion in mathematics. The focus of the program is engineering majors that need work in precalculus. While many of our entering students fall into this category, engineering paradigms begin with Calculus I. As many of the courses in the engineering curricula list the calculus sequence as prerequisites, students that do not take Calculus I the first semester of their freshman year are "off-track" until they take a math course in summer school. We restructured the first semester math experience to include both Precalculus & Calculus I. Students have nine contact hours per week of mathematics earning six hours of credit. We reordered the topics to provide additional reinforcement of key concepts. We believe that students succeed in learning the material with stronger algebraic skills than those taking the traditional route of Precalculus followed by Calculus I. We taught our fourth cohort of MIFE in Fall 2008. In this paper, we share some of our results, successes, and challenges. (Received September 15, 2008)

1046-Z1-1356 **Josh W. Helms*** (josh.helms@usma.edu), MADN-MATH, 646 Swift Road, West Point, NY 10996, and **Rodney Sturdivant**. *An Interdisciplinary Project for Statistics and Physics.* Preliminary report.

This talk will discuss an interdisciplinary project between a university's math and physics departments. We developed a statistical analysis project that analyzed the data our students produced in a physics RC circuit lab. We will discuss the project as well as the benefits and drawbacks experienced by the students and the departments. (Received September 15, 2008)

1046-Z1-1370 **Edwin P Herman*** (eherman@uwsp.edu), Department of Mathematical Sciences, University of Wisconsin, Stevens Point, Stevens Point, WI 54481. *Which is better: homework or quizzes?* Preliminary report.

Graded homework assignments and quizzes are both popular formative assessment methods. Each one has its proponents, and some instructors use both in their classes. It would be valuable to know which (if either) is better at promoting student ability in mathematics courses. Literature on this question is scarce, so I decided to investigate it myself. To focus my research, I have tried to find out which of the two assessment methods tends to produce higher exam scores in students.

For the last year and a half I have studied student performance in my classes. Each semester I taught two sections of a lower division course. For the first exam, students in one section turned in weekly homework assignments, while students in the other section took quizzes on the same set of questions. At each subsequent exam the requirements were switched. A statistical analysis was performed for each semester to see if either method produced significantly higher results.

Additionally, I sent out a survey this fall to math professors around the country regarding homework/quiz practices. In my presentation, I will discuss the statistical results of my study and the summary results from the survey. Student feedback on which method they thought was more helpful will also be presented. (Received September 15, 2008)

1046-Z1-1411 **Nathan W Hall*** (nhall@whalls.com), 909 22nd St Apt 8, Bellingham, WA 98225, and **Daisy L Phillips**, **Laina Mercer** and **Amy D Anderson**. *A simulation study comparing methods of estimating inbreeding coefficients.*

An inbreeding coefficient is the probability an individual with two identical alleles received both alleles from one ancestor, and can be estimated for a population through analysis of genotype data. We developed a method using maximum likelihood estimators and an expectation maximization algorithm to estimate inbreeding coefficients using known allele frequencies. The method was evaluated using simulated data and data collected on wild mice (Mus musculus) in Arizona. Our results were compared with those obtained using several other commonly used methods, specifically Ritland's (1996) method, a Simple ad hoc method which has been used by several researchers, and modified versions of these. Our results with the mouse data confirm the results of other studies: mice in the wild are significantly inbred. The MLE and Simple methods agreed well, while Ritland's estimators displayed some disagreement with both. Overall, each method was successful with minor strengths and weaknesses depending on the amount of genotype data available and distribution of allele frequencies. Our MLE method worked virtually as well or better than the other methods in most cases. (Received September 15, 2008)

1046-Z1-1415 **Daisy L Phillips*** (`philli5@cc.wwu.edu`), 1446 Franklin St. Apt. A, Bellingham, WA 98225, and **Nathan W Hall**, **Laina Mercer** and **Amy D Anderson**. *Methods of estimating inbreeding coefficients by jointly estimating allele frequencies and accounting for the presence of null alleles.*

An organism receives two alleles at each locus: one from its mother and one from its father. If these two alleles are identical copies of the same allele from an ancestor that both parents share, we say that they are "identical by descent", or IBD. The inbreeding coefficient for an individual is the probability that these two alleles are IBD. Various methods exist to calculate inbreeding coefficients using already known or previously estimated allele frequencies. In practice, these frequencies are calculated without allowing for the presence of null alleles or the possibility that individuals in the sample may be inbred. We developed two iterative algorithms that use the method of maximum likelihood to estimate inbreeding coefficients. One jointly estimates population allele frequencies and inbreeding coefficients and the other additionally accounts for the possible presence of null alleles. We ran a simulation study using these algorithms, and concluded that jointly estimating allele frequencies does not significantly affect the estimation of individual inbreeding coefficients. However, by accounting for the presence of null alleles greater accuracy in the estimation of inbreeding coefficients may be achieved. (Received September 15, 2008)

1046-Z1-1449 **Lucio M.G. Prado*** (`lprado@bmcc.cuny.edu`) and **Abdramane Serme** (`aserme@bmcc.cuny.edu`), Department of Mathematics - BMCC, The City University of New York, 199 Chambers Street, New York, NY 10007-1097. *Discriminating graphs of third degree polynomial functions.*

The talk will focus on an algebraic criterion for third degree polynomial functions with real coefficients. It allows to discriminate zeros, graphs, local maximum, local minimum, and inflection point, similarly, to the discriminant of second degree polynomial functions. Also, it can be used as tool to check the accuracy of the shape of a graph plotted by using computer algebra systems. This criterion can be taught in precalculus level course, since it does not require any calculus' technique.
(Received September 15, 2008)

1046-Z1-1452 **Richard J. Marchand*** (`richard.marchand@sru.edu`), Department of Mathematics, 009 Patterson Hall, Slippery Rock University, Slippery Rock, PA 16057, and **Timothy J. McDevitt**. *Stabilizing vibrating beams with point-load damping.* Preliminary report.

An analysis of the stabilization of a vibrating elastic beam using point-load damping will be presented. The rate at which the system is stabilized depends on the location of the point-load. Animations showing the behavior of the spectrum and the beam itself will be used to demonstrate the level of effectiveness of the damping. (Received September 15, 2008)

1046-Z1-1454 **Ala' Jamil Alnaser*** (`alnaser@math.ksu.edu`), Department of Mathematics, Kansas State University, Manhattan, KS 66502. *Waring's Problem in Number Fields.* Preliminary report.

Let p be an odd prime and $\gamma(k,p^n)$ be the smallest positive integer s such that every integer is a sum of s k-th powers $\pmod{p^n}$. Earlier we established $\gamma(k,p^n) \leq [k/2]+2$ and $\gamma(k,p^n) \ll \sqrt{k}$ provided that k is not divisible by $(p-1)/2$. Also if $t=(p-1)/(p-1,k)$, and q is any positive integer, we showed that if $\phi(t) \geq q$ then $\gamma(k,p^n) \leq c(q)k^{1/q}$ for some constant $c(q)$. These results generalized results known for the case of prime moduli. Here we generalize these results to a number field setting. Let F be a number field, R it's ring of integers and P a prime ideal in R that lies over a rational prime p with degree of inertia f. Let $\gamma(k,P^n)$ be the smallest integer s such that every algebraic integer in F that can be expressed as a sum of k-th powers $\pmod{P^n}$ is expressible as a sum of s k-th powers $\pmod{P^n}$. We prove for instance that when $t=(p^f-1)/(p-1,k)$ then $\gamma(k,P^n) \leq c(t)p^{nf/\phi(t)}$. (Received September 16, 2008)

1046-Z1-1456 **Maria C. Walpole*** (mariawalpole@kings.edu), 17 Sutherland Rd, Hicksville, NY 11801. *A Cunning Trap Must be Set!*

The mischief of a chalk-stealing nymph has plagued the Mathematics department of Kings College since its foundation in 1946. Thankfully, generations of professors have been carefully recording the robberies as they occur. Through some careful analysis, a set of rules are developed from the data, and a mathematical model is studied. In this talk a difference equation is derived with the use of a generating function, while other methods are explored as well. The model is used to predict the ramifications of his future behavior, as well as to determine a method to best outsmart the nymph! Furthermore, if time permits, some numerical analysis based on this model will be provided. (Received September 15, 2008)

1046-Z1-1465 **Michael Miner*** (jcmhs77@aol.com), 65 Edenbrook Drive, Suite 310, Hampton, VA 23666, and **Darcel Ford** (dford64@comcast.net), 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.* Preliminary report.

This paper seeks to compare distance and classroom learning of college algebra in terms of efficiency and effectiveness. The study seeks 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 seeks to discover evidence based methods to maximize teaching and learning outcomes for all stakeholders. The current search 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 15, 2008)

1046-Z1-1468 **Theresa Lynn Jeevanjee*** (tjeevanjee@fontbonne.edu), 6800 Wydown Boulevard, St. Louis, 63105. *Group Work: Motivation, Challenges, and How to Make it Work.* Preliminary report.

Companies regularly tell universities: "Give us students who can think, write and work in teams, we'll do the rest." Working in teams (or groups) is particularly difficult in a university setting because of the need to assess individual progress. The presenter shares some of her ideas and success stories for making group work a success both in and out of the classroom. (Received September 15, 2008)

1046-Z1-1508 **Bill Wood*** (wood@hendrix.edu), 1600 Washington Ave, Conway, AR 72032. *A Project-Oriented Undergraduate Course in Discrete Geometry.*

We describe a discrete geometry course offered to junior-level mathematics and computer science students at Hendrix College. The course was specifically designed to prepare students for senior research projects, and we illustrate how this topic can showcase the interplay of different fields of mathematics and their connections to computer science and other applications, as well as sharpen problem-solving and oral and written communication skills. (Received September 15, 2008)

1046-Z1-1514 **Pablo Zafra** (pzafra@kean.edu), Kean University, Department of Mathematics, C-233, 1000 Morris Ave, Union, NJ 07083, **Louis M Beaugris*** (lbeaugri@kean.edu), Kean University, Department of Mathematics, C-233, 1000 Morris Ave, Union, NJ 07083, and **Kikombo Ngoy** (kngoy@kean.edu), Kean University, Geology/Meteorology Dept., Union, NJ 07083. *The Kean STEM Scholarship Program: Successes in Recruitment and Retention of Math and Science Majors.*

The Kean STEM Scholarship Program (KSSP) is a $387,800 four-year grant funded by the National Science Foundation. KSSP is designed to increase recruitment and retention of majors in mathematics and the sciences at Kean University by providing scholarships to qualified students. We will detail our experiences and activities, and share our successes in this endeavor from the grant writing process, to faculty involvement and our first graduates. (Received September 17, 2008)

1046-Z1-1516 **Janet L. Braunstein*** (janet.braunstein@usma.edu), United States Military Academy at West Point, Department of Mathematical Sciences, Thayer Hall, West Point, NY 10996. *Promoting Responsibility and Cooperation Through the Use of Discussion Boards.*

At the U.S. Military Academy at West Point, we stress the importance of assuming responsibility for one's own learning. Students read the material to be covered in the next day's lesson and attempt related problems the night before. Most students' high school math classes do not follow this model, so the transition is often difficult. To aid in the process, we introduced the use of the Discussion Board feature in Blackboard in a first-semester multivariable calculus course for students in the Advanced Mathematics Program, a two-semester sequence for approximately the top 175 math students in each incoming freshman class.

Students can contribute to forums on a daily basis by posing questions about what they are reading, answering questions others have asked, or organizing study sessions. Such a system has promoted responsibility, cooperation, and pride among the students and has translated into a more positive classroom environment. The instructor can more easily judge where the students stand, and discussions arising in the forums can be continued in class. We will discuss pros and cons thus far, with suggestions for improvement next semester, and include screenshots of the actual forums. (Received September 15, 2008)

1046-Z1-1573 **Heather A Lewis*** (hlewis5@naz.edu), Nazareth College, Department of Mathematics, 4245 East Avenue, Rochester, NY 14618-3790. *Math Mistakes that Make the News.* Preliminary report.

Pounds are used instead of kilograms. A plus sign and minus sign are switched. On an exam, this might mean only a few lost points; in real life, however, errors such as these have sometimes had notable consequences. Several such examples will be shared. (Received September 16, 2008)

1046-Z1-1583 **Jeffery T McLean*** (jtmclean@stthomas.edu), University of St. Thomas, 201 OSS, St. Paul, MN 55105. *Circluar Insights into Geometry.*

An investigation of the use of Geometer's Sketchpad constructions to lead students to insights about euclidean geometry and algebraic and transformational techniques that may be applied to problem solving. (Received September 16, 2008)

1046-Z1-1604 **Karl-Dieter Crisman*** (karl.crisman@gordon.edu), 255 Grapevine Road, Wenham, MA 01984. *Math in Your Dorm Room - from Calculus to Number Theory - with Sage.* Preliminary report.

An ideal way to capitalize on a novel demo, interactive or otherwise, is to have students continue to explore with it in new directions as part of their homework assignment. Often this is done with problem-specific applets, but this is not comprehensive; on the other hand, asking students at institutions without a site license for a commercial program to go to one of the few copies in a remote computer lab is also not ideal. Here, we describe using the free mathematical software package Sage to take classroom demonstrations in the full range of math courses into the dorm room, via a use-anywhere web browser interface. We discuss student response to the sort of non-routine (even quite exploratory) assignments and labs this made possible, as well as to the technology itself. (Received September 16, 2008)

1046-Z1-1660 **Nancy Donaldson**, **Mairead Greene**, **Volker Ecke** and **Christine VonRenesse*** (cvonrenesse@wsc.ma.edu). *The Role of an Inquiry-Based Classroom in Undergraduate Mathematics.* Preliminary report.

We are currently designing a research program to investigate the way in which an inquiry-based classroom influences an undergraduate's attitude to and learning of any level of mathematics. We began by focusing on two aspects of this: how to define an inquiry-based classroom and how to measure student's attitude towards mathematics. To solve the first problem, we turned to the Reformed Teacher Observation Protocol (RTOP) developed at Arizona State University. To address the second problem, we are currently working to adapt the validated CLASS-Physics, a survey which measures students' attitudes to physics, for mathematics. We have begun working on this by creating our own survey based on the questions found in the CLASS-Physics. In the future, we would like to find an effective way to measure critical thinking ability and conceptual understanding in our undergraduates. We would then hope to put these pieces together to develop an assessment of the role of the inquiry-based classroom in undergraduate mathematics education. In our talk, we will present our work to date and discuss our future goals. We welcome all thoughts and suggestions! (Received September 16, 2008)

1046-Z1-1676 **Eugene C. Boman*** (ecb5@psu.edu), Penn State, Harrisburg campus, Middletown, PA 17057. *Ghosts of Departed Errors: Berkeley's Mathematical Objections to the Calculus of Newton and Leibniz.*

In 1734 George Berkeley, Bishop of Cloyne, published *The Analyst* wherein he took issue with the foundations of calculus as they were then understood. This is arguably one of the most important documents in mathematics as the next 200 years of foundational work can be viewed as the mathematics community's attempt to respond to Berkeley's criticism. Unfortunately, only his famous sarcasm, referring to differentials as the "ghosts of departed quantities," is well known today. I will present and examine the mathematical criticisms offered in *The Analyst* and some of the early attempts at answering them. (Received September 16, 2008)

1046-Z1-1683 **Christopher C Leary*** (leary@geneseo.edu), Department of Mathematics, SUNY Geneseo, 1 College Circle, Geneseo, NY 14454, and **Aaron Heap**. *Effect of WeBWorK on Student Performance in Calculus II.* Preliminary report.

In an attempt to investigate the effect of using a web-based homework system on student learning, two parallel sections of Calculus II were offered during the fall semester of 2008. One section had all of its homework assigned out of the textbook, while the other section was assigned the majority of its homework problems via WeBWorK. We report on our study design and give a preliminary report of our results. (Received September 16, 2008)

1046-Z1-1688 **Stephen D Szydlik*** (szydliks@uwosh.edu), Mathematics Department, University of Wisconsin-Oshkosh, 800 Algoma Blvd., Oshkosh, WI 54901-8631. *A Moment of Truth: Teaching an Honors Seminar Course.*

Truth, even in mathematics, can be a notoriously difficult concept to pin down. While the structure and logic of pure mathematics provides us with a measure of certainty unavailable to other disciplines, issues of incompleteness (see the work of Gödel) and the nature of proof (e.g. see Lakatos' *Proofs and Refutations*) nevertheless warn us that absolute conviction remains elusive even in mathematics.

During the Fall 2008 semester, the author had the distinct privilege of teaching a freshman honors seminar course at the University of Wisconsin-Oshkosh. Team-taught with a member of the English department, the course focused on issues of truth and uncertainty in mathematics and the humanities. In this presentation, the author will describe his experience in teaching the course, including the topics discussed, the format of the class and the challenges of working with talented but mathematically diverse students. (Received September 16, 2008)

1046-Z1-1689 **Haishen Yao*** (hyao@qcc.cuny.edu), Dept. of Math and Computer Sci., Queensborough Community College, 222-05 56th Ave., Bayside, NY 11364. *A few new approaches to teach remedial math in the college.* Preliminary report.

CUNY is the largest urban university in the US, there are a lot of needs of remedial mathematics courses needed in the sixteen colleges. In part as a result of CUNY's open enrollment policy, Queensborough Community College receives many students who are not ready to take credit bearing courses in subjects like mathematics. Unless a student has demonstrated a sufficient score on a Regent exam or SAT exam, the student is required to take the COMPASS exam with the result that almost half of our entering students are placed in MA005 (Arithmetic), MA010(Basic Algebra),Math 013(Basic Algebra).

These courses review materials that were presented in high school or earlier but the passing rate in these courses varies below 50%. Many of the students enrolled are repeaters. Resources of the College are wasted and students are prevented from advancing in their academic career. We will discuss our several approaches to solve this problem, such as problems center approach, diagnostic approach, community learning approach and self pace approach. Our pedagogical research shows some promising results in these approaches. (Received September 16, 2008)

1046-Z1-1722 **Rachel Schwell*** (schwellrac@ccsu.edu), Department of Mathematical Sciences, Central Connecticut State University, 1615 Stanley St., New Britain, CT 06050. *Bite-Sized Exams: A Tale of Two Pre-Calcs.*

It is well known that students, in particular those who struggle with mathematics, perform better when they are encouraged to study and demonstrate small amounts of material at a time. In this talk we compare students' performance and feedback in two sections of pre-calculus with trigonometry taught in the same semester by the same instructor, one of the sections having followed a standard testing format (weekly quizzes, three semester exams) while in the other the students were given alternating weekly quizzes and mini-exams. In particular, the students' performance on the final exam, which was common to both sections, will be discussed. (Received September 16, 2008)

1046-Z1-1725 **Julius N Esunge*** (esunge@math.lsu.edu), Department of Mathematics, 329 Lockett Hall, Baton Rouge, LA 70803. *Characterization of Compactness in Classical Banach Spaces.*

In this work, we present criteria for compactness in some infinite-dimensional Banach spaces. In particular, we discuss this notion for subsets of $C(M)$, (M - compact), ℓ^p and L^p, $1 \leq p < \infty$. In each case, we state and prove conditions under which a subset of the given space is compact. (Received September 16, 2008)

1046-Z1-1729 **Randy Boucher*** (randy.boucher@usma.edu), Dept of Math Sciences, U.S. Military Academy, 646 Swift Road, West Point, NY 10996, and **Janet Braunstein** and **Donald Outing**. *The Advanced Mathematics Program at the United States Military Academy: Exposing Students to Technology through a Rigorous Mathematics Curriculum.* Preliminary report.

The USMA Advanced Mathematics Program is a one-year program designed for a subset of freshmen with prior calculus experience. It consists of a rich treatment of multi-variable calculus, including infinite series and vector calculus, followed by an introductory ordinary differential equations course. Historically, two-thirds of these students choose a Science, Technology, Engineering, or Mathematics major. Over the past fifteen years, the integration of technology into the classroom has changed in many ways in our program. In this presentation, we will provide a brief history of our efforts to integrate technology into our curriculum. We will discuss lessons learned and the road ahead. We will focus on how we currently teach with technology and require students to learn with technology. Finally, we will share a few successful strategies for assessing the technological part of the curriculum. (Received September 16, 2008)

1046-Z1-1733 **Richard H. Stout*** (richard.stout@gordon.edu), Department of Mathematics, Gordon College, Wenham, MA 01984. *Developing Modern Algebra and Perspectives on the Nature of Mathematics in Victorian England.*

Algebra underwent significant changes in the 1800's, with much of the work done in England and Ireland. This talk will briefly introduce several of the people involved in its development, focusing on how it affected their perception of the nature of mathematics. (Received September 16, 2008)

1046-Z1-1740 **M. Leigh Lunsford** and **Phillip Poplin*** (poplinpl@longwood.edu), Department of Mathematics and Computer Sci., Longwood University, 201 High Street, Farmville, VA 23909. *Basic Mathematical Skills and Success in Introductory Level Statistics.*

The objective of our study to was determine if there is a relationship between students' basic mathematical skills and their success in introductory level statistics classes at Longwood University. We were also interested in determining if the use of free tutoring available at the Longwood University learning center contributed to student success.

To measure basic mathematical skills, we used a test developed by [1]. Our dataset was collected over the course of two academic years and contains information on over 700 students including their basic skills test score, their final grade in the class, their professor, and whether they received tutoring from the Longwood University learning center. We found a strong association between basic math skills and success in the course, even when controlling for professor. These results are consistent with [1]. We did not find a significant association between use of the free tutoring in the learning center and student success. These results have influenced the way we teach our introductory statistics courses.

1. Johnson, Marianne and Kuennen, Eric "Basic Math Skills and Performance in an Introductory Statistics Course," Journal of Statistics Education Volume 14, Number 2 (2006), www.amstat.org/publications/jse/v14n2/johnson.html (Received September 16, 2008)

1046-Z1-1770 **Subhash C. Saxena*** (saxenas@coastal.edu), 4407 Green Bay Trail, Myrtle Beach, SC 29577. *Enhance rigor in College Geometry with technologies of Sketchpad, Cabri, or Cinderella.*

Proof is central to learning geometry at the college level and higher mathematical thinking. Instead of making it cut and dry, we can enhance the rigor by integrating dynamic geometry software for exploration and discovery. Explorations with the technology of Sketchpad, Cabri, or Cinderella lead to conjectures and in many cases help in the development of proofs. Some explorations produce "Aha" experiences. Rigor and usage of technology are not mutually exclusive. Cleverly designed continuous motion on figures carefully constructed in any of the three software can produce convincing confirmation of theorems, leaving lasting impressions. This presentation will deal with the strength of each of these three technologies in the instruction of geometry at the college level. (Received September 16, 2008)

1046-Z1-1775 **Deborah A Koslover*** (dkoslover@uttyler.edu), University of Texas at Tyler, Department of Mathematics, RBN 4010, 3900 University Blvd, Tyler, TX 75701. *Foundations of Mathematics, Survivor!*

The popular television show Survivor was imitated to motivate students in an introduction to proofs course. Unlike the TV show, the goal of the game was to keep as many students as possible on the island (pass the class). Weekly challenges, in the form of games and puzzles, were assigned to small teams of students to enhance course content and to encourage social interaction and consequent formation of study groups. Several of these challenges will be discussed as well as the positive reaction of the students to the course. (Received September 16, 2008)

1046-Z1-1776 **Juliana V. Belding*** (jbelding@math.umd.edu), Dept. of Mathematics, Harvard University, Cambridge, MA , and **Eden M. Badertscher**, Institute of Learning, University of Pittsburgh, Pittsburgh, PA. *Posing and Pursuing One's Own Questions: Comparing Experiences of Graduate Students in Math Education and Mathematics.* Preliminary report.

If we want students and educators to be life-long learners and doers of mathematics, we need to provide them the opportunity to pose and pursue their own mathematical questions. This was the goal of a course for graduate students in math education at the University of Maryland in which participants engaged in both communal investigations and individual projects. We describe the course structure and experience, with a focus on how to best support the transition to inquiry.

We also discuss a case study of a first-year graduate student in mathematics enrolled in the course. This data suggests the potential such a course has to enrich the early years of the graduate math program for students with dual interests in math and teaching, as well as to foster interaction between graduate students in both disciplines which may be of use in their professional futures. (Received September 16, 2008)

1046-Z1-1779 **Heather Cavell** (hcavell@email.arizona.edu), CEMELA Central Office, Dept. of Mathematics, University of Arizona, 617 N. Santa Rita, Tucson, AZ 85721, **Liana Dawson** (ldawson@math.arizona.edu), CEMELA Central Office, Dept. of Mathematics, University of Arizona, 617 N. Santa Rita, Tucson, AZ 85721, **Kathleen Ross** (ross3141@email.arizona.edu), CEMELA Central Office, Dept. of Mathematics, University of Arizona, 617 N. Santa Rita, Tucson, AZ 85721, and **Belin Tsinnajinnie*** (belin@math.arizona.edu), CEMELA Central Office, Dept. of Mathematics, University of Arizona, 617 N. Santa Rita, Tucson, AZ 85721. *Bilingual and English language learners understanding and solving mathematics problems.* Preliminary report.

English Language Learners confront immense cognitive demand in meeting the linguistic demands of mathematical tasks, and in negotiating the demands of academic language in mathematics class. To be adequately prepared for college preparatory mathematics coursework in middle school and high school, academic language used in the context of mathematical discourse offers benefits and challenges for all students, but also requires consideration of the additional cognitive demands for students with linguistic needs. In this study, students were given items modified from the National Assessment of Educational Progress (NAEP) mathematics assessment. A task-based interview protocol was used to investigate students' understanding of the problems and their solution strategies, and provide opportunities to ask questions about problem wording. We will discuss the preliminary findings from interviewing 7 sixth graders. Language usage and preference data will inform analysis of the variability of experiences depending on level of English language acquisition, using grounded theory and constant comparison qualitative methods. (Received September 16, 2008)

1046-Z1-1801 **ximena catepillan*** (ximena.catepillan@millersville.edu), Millersville University, Department of Mathematics, PO Box 1002, Millersville, PA 17551, and **waclaw szymanski** (wszymanski@wcupa.edu), West Chester University, Department of Mathematics, West Chester, PA 19382. *Ancient Inca Mathematics.* Preliminary report.

The Inca Empire - the greatest pre-Columbian empire on the American continent - extended from Ecuador to central Chile for more than five thousand miles. Its capital Cuzco was established in the high Peruvian Andes.

This highly advanced civilization developed a decimal system used to run the empire - in particular, to build the 14,000 mile road structure and monumental architecture.

Some of the algorithms believed to be used by the Inca to do computations using a "yupana", an ancient calculating device, will be presented, as well as classroom activities for the course "Mathematics in Non-European Cultures" for non mathematics and science majors offered at Millersville University. (Received September 16, 2008)

1046-Z1-1834 **Robert D. Poodiack*** (rpoodiac@norwich.edu), Department of Mathematics, Norwich University, 158 Harmon Drive, Northfield, VT 05663. *The Power of Five.*

There's something about the "fifth level" of difficulty in mathematics, an invisible barrier which seems to separate the solvable from the unsolvable in several problems. We will look at three such problems and try and figure out what separates the fifth level, the fifth power, from the four that come before it and raises difficulty to impossible levels. (Received September 16, 2008)

1046-Z1-1843 **Shane P Redmond*** (Shane.Redmond@eku.edu), 313 Wallace Bldg, 521 Lancaster Ave., Eastern Kentucky University, Richmond, KY 40475. *Zero Product Sequences in Commutative Rings.* Preliminary report.

Let R be a commutative ring. A *zero product sequence* (or *zps*) is a sequence $\{a_1, a_2, ..., a_n\} \subseteq R$ such that $a_1 \cdot a_2 \cdots a_n = 0$ with each $a_i \neq 0$. A *minimal zps* is a *zps* such that no subsequence is also a *zps*. Define the *zps constant* for R, denoted $D_z(R)$, to be the supremum of the lenghths of every minimal *zps* of R. Several examples and consequences of this definition are given, as well as applications to the study of zero-divisor graphs. (Received September 16, 2008)

1046-Z1-1852 **Aprillya Lanz*** (lanzar@vmi.edu), Dept. of Mathematics and Computer Science, 430 Mallory Hall, Lexington, VA 24450, and **Ana Tameru** (atameru@alasu.edu), Department of Mathematics, 915 S. Jackson St., Montgomery, AL 36101. *Solution Matching for a Second Order Boundary Value Problem on a Time Scale.*

We will show the existence and uniqueness of solution for a boundary value problem

$$y^{\Delta\Delta}(t) = f(t, y(t), y^{\Delta}(t)), \quad t \in [a, b]_{\mathbb{T}}$$
$$y(a) = A, \quad y(b) = B,$$

by matching the solution of the two-point boundary problem on $[a, c]_{\mathbb{T}}$ with the solution of the two-point boundary value problem on $[c, b]_{\mathbb{T}}$ where $c \in (a, b)_{\mathbb{T}}$. (Received September 16, 2008)

1046-Z1-1869 **Jennifer K Angelosante*** (angeloj@cc.wwu.edu), Department of Mathematics BH-202, Western Washington University, 516 High St., Bellingham, WA 98225-9063, and **Amy Anderson**. *Estimating Relatedness Using Markov Chain Monte Carlo Techniques.*

The degree of genetic relatedness between two individuals can be described using a set of three parameters that indicate the probabilities that, at a random chromosomal location, the pair will share 0, 1, or 2 pairs of genetic variants identical by descent from a common ancestor. The estimation of these parameters has a variety of applications including forensics, human disease mapping and plant/animal breeding. Previous studies have developed relatedness estimators for subpopulations that have diverged from a population for which population allele frequencies are known, but require that the user specify a value that gives the degree of divergence. We developed an estimator that considers the degree of divergence to be an unknown parameter to be jointly estimated with the relatedness parameters. Our goal was to estimate how related two individuals from a common subpopulation are and how far this subpopulation has diverged from an original population. (Received September 16, 2008)

1046-Z1-1891 **Elijah Miguel Allen***, 1413 Blakeley st, Savannah, GA 31406. *Arbitrary Roughness.*

When are 4n+1 and 4n+3 both prime? What values of n make 2n+1, 4n+3, and 8n+7 all prime at the same time? With the theorems presented in this paper the required conditions a value n must meet are seen and used to develop an algorithm to find such numbers. Finally, it is shown that for any set of arithmetic progressions that do not represent a complete residue set for any prime that there exist infinitely many n such that the entire set is arbitrarily rough and what this means towards solving problems like the twin prime conjecture. (Received September 16, 2008)

1046-Z1-1892 **Gabriela R Sanchis*** (sanchisgr@etown.edu), Elizabethtown College, Department of Mathematical Sciences, Elizabethtown, PA 17022. *Mathematica Laboratory Assignments Inspired by the History of Mathematics.* Preliminary report.

Many problems from the history of mathematics can be made accessible to undergraduates through the use of technology. I will discuss several computer lab assignments, inspired by the history of mathematics, that I have designed for use in undergraduate classes, including calculus and linear algebra. (Received September 16, 2008)

1046-Z1-1895 **Tom McMillan** (tcmcmillan@ualr.edu), 2801 South University Ave, Dept Math/Stat, Univ of Arkansas at Little Rock, Little Rock, AR 72204-1099, and **Jim Fulmer*** (jrfulmer@ualr.edu), 2801 South University Ave, Dept Math/Stat, Univ of Arkansas at Little Rock, Little Rock, AR 72204-1099. *Visualizing Continuity and Differentiability of Functions of Two Variables.*

In this talk, we will examine differentiability and continuity of functions of two variables. When moving from one variable functions to two variable functions, the extra dimension complicates student understanding of both continuity and differentiability. Proofs found in textbooks are technically correct but typically do not shed light on the examples in the same way that graphs of one variable functions do. In our presentation, we illustrate how to use cylindrical coordinates to understand why a function fails to be continuous (or differentiable) at a point. The ideas we illustrate help students to understand these concepts and empower them to develop their own examples. (Received September 16, 2008)

1046-Z1-1933 **Carrie Muir*** (Carrie.Muir@Colorado.edu), Department of Mathematics, 395 UCB, Boulder, CO 80309-0395. *Evaluating the Success of a Calculus Placement Test: Aligning the Basis for Placement and the Basis for Assessment.* Preliminary report.

Many institutions use a test of mathematical knowledge and skills to determine, at least in part, course placement. However, when the success of such a placement test is evaluated, the most common measure is students' final grades in the course. I will argue that final course grade is not an appropriate outcomes measure for student placement based on a knowledge and skills based test, and will present alternative outcomes measures. Preliminary results from a study of a proposed Calculus Readiness Test will also be presented. (Received September 16, 2008)

1046-Z1-1952 **Nermin Bayazit*** (nt04@fsu.edu), 205 Stone Building, School of Teacher Education, Florida State University, Tallahassee, FL 32306. *Role of Mathematical Definitions in Proof: A Case of Prospective Mathematics Teachers.* Preliminary report.

This study investigated preservice mathematics teachers' perceptions of mathematics, mathematical definition and proof as well as their use of mathematical definitions in doing proof. Five secondary mathematics education students were interviewed four times. The focus of the first interview was on their perceptions of mathematics, mathematical definitions and proof. The other three interviews focused on their understanding of a given definition, use of definitions in doing proofs and assessment of the validity of a given proof in three content areas: set theory, geometry, and linear algebra. The initial findings of the study showed a connection between students' perceptions of mathematics and proof, and their approaches to proof. In addition to this, it has been observed that students' previous knowledge can be a barrier for their understanding of a given definition or using the definition to construct a proof.

Key words: Proof, mathematical definition, prospective teachers (Received September 16, 2008)

1046-Z1-1958 **Ian Whitacre*** (ianwhitacre@yahoo.com), Department of Mathematics and Statistics, San Diego State University, 5500 Campanile Drive, GMCS 415, San Diego, CA 92182. *A Simple Geometer's Sketchpad Sketch for Exploring Ideas of Function.*

This presentation addresses the need for demonstrations and strategies with technology that enhance teaching and learning of mathematics. The presenter will describe and demonstrate an interactive lesson around ideas of function from a conceptual course in algebra and rates of change. The presenter will demonstrate the use of a simple Geometer's Sketchpad Sketch of a position-time graph, including questions that ask students to make predictions and to justify their conjectures. The lesson addresses ideas of function and, in particular, the vertical line test. This lesson has been used with preservice teachers. It would also be suitable for use with in-service teachers or secondary school students. (Received September 16, 2008)

1046-Z1-1969 **Leyla Batakci*** (batakcil@etown.edu), 1 Alpha Dr., Elizabethtown, PA 17022, and **Keri A. Speicher** (speicherk@etown.edu), Elizabethtown, PA 17022. *Online Homework Delivery in an Introductory Statistics Course.* Preliminary report.

There is no question that homework is one of the most important learning tools in mathematics and science classes. The effectiveness of this tool is greatly enhanced when students can get timely feedback on their assignments. Unfortunately, in large classes it is virtually impossible for the instructor to collect homework on a daily basis, and then grade and return homework in a timely manner. A solution to the above concern is to use an internet-based homework delivery system. There are a few systems available to automate the collecting and grading homework. We adopted WebAssign as the internet-based homework delivery system in our introductory level statistics course. We will discuss the benefits and difficulties of our experience with Webassign. (Received September 16, 2008)

1046-Z1-1978 **Russell D Blyth*** (blythrd@slu.edu), Dept. of Mathematics and Computer Science, Saint Louis University, 220 N. Grand Blvd., St. Louis, MO 63103, and **Julianne G Rainbolt** (rainbolt@slu.edu), Dept. of Mathematics and Computer Science, Saint Louis University, 220 N. Grand Blvd., St. Louis, MO 63103. *Discovering Theorems in Abstract Algebra using GAP.*

We describe a method that helps students in an abstract algebra course discover classical theorems before they are stated and proved, with the help of leading questions and the software Groups, Algorithms and Programming (GAP). We illustrate the method with several examples. (Received September 16, 2008)

1046-Z1-2004 **John D Pesek*** (pesek@udel.edu), Food & Resource Economics, 213 Townsend Hall, University of Delaware, Newark, DE 19713. *Generalizations of Varignon's and Steiner's Theorems to Simplexes Using Set Partitions.*

Set partitions of the vertex set of a simplex can be regarded as a natural generalization of the concept of opposite side for triangles. Steiner's theorem for a tetrahedron says that sliding a pair of opposite edges along the lines containing them does not change the volume of the tetrahedron. A variant of Varignon's theorem says that if a plane is parallel to each of two opposite sidesof a tetrahedron, it cuts the tetrahedron in a parallelogram. In each case the pair of opposite sides is determined by a partition of the vertices of the tetrahedron into two two-element sets. If a simplex and a vertex partition are considered and we 'slide' the subsimplexes defined by the points in each block of the partition within the flats determined by the subsimplexes, volume is preserved. If a simplex and a vertex partition with k blocks are considered and the simplex is intersected by a flat of dimension $k-1$ less than that of the simplex which is parallel to each of the flats determined by the points in the blocks of the partition, then the flat intersects the simplex in a poly-simplex (a product of simplexes) with parallel 'sides' (A parallelogram is the product of two one-simplexes). A connection between these two results is also discussed. (Received September 16, 2008)

1046-Z1-2011 **Aaron Wangberg*** (awangberg@winona.edu), 322 Gildemeister Hall, Winona State University, Winona, MN 55987. *How was that picture helpful? Using online tablet-PC software and corrective self-explanation to increase student conceptual understanding in applied pre-calculus.* Preliminary report.

According to the prompted self-explanation principle, students will achieve higher learning gains when prompted to explain steps of worked examples than when they study the material without such prompting. A variation of this principle, called corrective self-explanation, prompts students to explain why worked examples are incorrect. In an introductory three week study, students in an applied pre-calculus course were asked to use an online tablet-PC based system which prompted them for self-explanation and corrective self-explanation of both instructor and peer-created solutions. In this talk, I will share how the tablet software was used in the study and report on how self-explanation affected student conceptual understanding. (Received September 16, 2008)

1046-Z1-2015 **Thomas B Fox*** (fox@uhcl.edu), 1 Camino Santa Maria #18, Casa Maria Community, San Antonio, TX 78228. *Developing Conceptual Underpinnings of the Derivative in courses before Calculus.*

An activity for developing the conceptual underpinnings of the derivative will be examined. Using the context of population change, average and instantaneous rates of change are studied. The activity also develops the following important characteristics of graphs: relative maxima/minima, concavity, inflections points, local linearity, and the increasing/decreasing behavior of a function's graph. The activity is suitable for students in either college algebra or a pre-calculus course; students need to be familiar with the concept of the slope of a straight line in order to successfully complete the activity. (Received September 16, 2008)

1046-Z1-2038 **Tracey Keck*** (keckt@wssu.edu), 601 S. Martin Luther King Jr. Drive, Winston Salem, NC 27110. *Problem-Centered Learning in Mathematics Education.*

Problem-centered learning involves three elements: tasks, groups, and sharing (Wheatley, 1991). The teacher selects challenging tasks, but students are not shown particular procedures for solving them. Rather they work in homogeneous pairs or small groups to devise their own meaningful solutions,and class members come together to share their different solution strategies with each other. The theoretical framework for a problem-centered learning environment is constructivism (von Glasersfeld, 1991). Learning occurs as students construct meanings for their experiences, and the learner acts and interacts with the world, actively trying to resolve conflicts while engaging in purposeful activity (Wood & Sellers, 1996). As students actively engage each other, they try to resolve personal conflicts or differences between their existing ways of thinking and the aspects of their experiences. Resolution of conflicts takes place during genuine communication among students and teacher. Communication in this sense is not linear, from teacher to student or student to teacher. Instead, it is a circular process involving all learners, whereby students actively share, respond, negotiate, and listen while striving to interpret the mathematical meanings embedded within an activity. (Received September 16, 2008)

1046-Z1-2051 **Sarah L Mabrouk*** (smabrouk@frc.mass.edu), Framingham State College, Mathematics Department, 100 State Street, Framingham, MA 01702-2499. *Using Online Discussions in an Introductory/Intermediate Algebra Course.*

Teaching an introductory/intermediate algebra course is challenging: the students have seen the material and, believing that they "know" the subject matter, tend to spend what seems like little or no time on valuable review and practice. Teaching such a course becomes tricky when it is noncredit and the students, placed into the course based on their performance on a placement exam, must successfully complete the course before they are allowed to take a credit bearing college-level mathematics course. Group work and in-class discussion of the course material are beneficial but this valuable practice must continue outside the classroom. Given the opportunity, students enjoy sharing their work. They also enjoy email, IM, interacting online, and using the Internet. Combining these provides a wonderful opportunity for student interaction, practice and review, and helping students to take ownership of course material as they discuss and present the exercises and applications to each other. In this presentation, I will discuss how I use email, IM, and online discussions in my noncredit General Mathematics course, the students' reaction to their use, the benefits for the students and the instructor, and the overall effect on student performance and student reaction to the course. (Received September 16, 2008)

1046-Z1-2053 **Brian J Lindaman*** (linda086@umn.edu), 830 Larpenteur Ave. Unit 1, Saint Paul, MN 55113. *Teaching Infinite Series: A Study on Students' Conceptual and Procedural Understanding of Infinite Series in Calculus.*

The topic of infinite series poses significant difficulties for students in second-semester calculus. Research on calculus reform projects of the past 15 years indicates non-traditional teaching strategies may improve students' conceptual understanding of topics in calculus. A recent study explored students' understanding of infinite series, and investigated the effects of reform-based instructional strategies on students' understanding of series. For the study, a Series Understanding Instrument (SUI) was developed and used to gather data on student understanding of series during the three-week teaching experiment. Instruction in one section of students utilized nontraditional classroom strategies and activities such as visualization, writing in class, and cooperative learning. Another section of students, taught with a traditional lecture-based approach, served as the control group. Three course assessments provided data on students' procedural understanding of series, and the SUI provided additional data on students' conceptual understanding of series. Results from these assessments will be presented during the session. Some results from subsequent research targeting high-ability students' conceptions of series will be discussed as well. (Received September 17, 2008)

1046-Z1-2054 **Rommel G Regis*** (rregis@sju.edu), Saint Joseph's University, Math & CS Dept., 5600 City Avenue, Philadelphia, PA 19131. *Recent Developments in Derivative-Free Optimization.* Preliminary report.

Classical optimization techniques utilize derivatives. However, many optimization practitioners have encountered practical problems in applying standard derivative-based methods. Moreover, recent studies have shown that some derivative-free optimization methods that utilize function approximation models such as radial basis functions perform better than standard derivative-based methods on practical problems where function evaluations are expensive. This talk will provide a brief survey of recent developments in derivative-free optimization. (Received September 17, 2008)

1046-Z1-2056 **Csilla Szabo*** (szaboc@rpi.edu), 5 Ahern Ave, Apt 3, Troy, NY 12180, and **Donald Drew**. *Do the Ends Justify the Lengths? Actin Polymer Length Distribution.*

Actin polymers form the cytoskeleton of cells, giving cells structural support and allowing for cell motility. They are also instrumental in axon (nerve cell) growth, where they determine the directions taken by the axons as they grow. Models for the growth of actin polymers are based on adding and/or deleting actin monomers from the ends of the polymers. Consequently, it is straightforward to track the ends of these actin polymers. A natural question to ask is given the probabilistic distribution of the growing and decaying positions of the ends of the polymers, does one know the polymer lengths? Knowing the distribution of positions of ends does not give adequate information for finding the polymer length distribution. I will present a model for the length distribution of these polymers in 1-dimension, which will maximize the entropy or randomness in the system. This gives the least biased estimate for the length distribution given the limited amount of information. (Received September 16, 2008)

1046-Z1-2079 **Stephen Devlin*** (smdevlin@usfca.edu), University of San Francisco, Mathematics Department, 2130 Fulton Street, San Francisco, CA 94117, and **Thomas Treloar**. *The Evolution of Cooperation on Random Networks.*

We study an evolutionary Prisoner's Dilemma on complex random networks. Using generating functions, we introduce a natural measure of network heterogeneity that can accurately predict, quantitatively, the equilibrium success of cooperators in the game. Moreover, the generating functional approach suggests an intrinsic interpretation for the heterogeneity of the network that helps explain local mechanisms through which cooperators thrive in heterogeneous populations. Finally, we give a simple relationship between heterogeneity, the cooperation level, and the epidemic threshold of a random network that reveals an appealing connection between epidemic disease models and the evolutionary Prisoner's Dilemma. (Received September 17, 2008)

1046-Z1-2097 **Kevin K Ferland*** (kferland@bloomu.edu), Mathematics Department, Bloomsburg, PA 17815. *Toughness Extended to Infinite Graphs.*

A study of the toughness of infinite graphs is initiated by considering a natural generalization of that for finite graphs. After giving some general results, several open problems are presented. (Received September 17, 2008)

1046-Z1-2104 **Jennifer C McLoud-Mann*** (jmcloud@uttyler.edu), 3900 University Blvd, Tyler, TX 75799. *Lessons Learned from a Calculus Redesign Project.*

In this talk we will discuss the lessons learned from a Calculus Redesign project involving on-line instruction. Unlike traditionally redesign projects, both the redesigned course and the regular course were taught at the same time. We will focus the talk on comparative data for students in both kinds of sections. Questions to be addressed include: How do the student outcomes compare (especially on the common final exam)? How do students feel about taking these courses? What adjustments can be made in the future to improve the courses we offer? (Received September 17, 2008)

1046-Z1-2107 **Travis Kowalski*** (travis.kowalski@sdsmt.edu), South Dakota School of Mines and Technology, Department of Mathematics, 501 East Saint Joseph Street, Rapid City, SD 57701. *Teaching calculus through experimentation and empiricism.* Preliminary report.

Students dislike mathematics because of its static presentation as an endless list of rules and formulas. Can it instead be presented so that students devise hypotheses about different calculus concepts and test them with empirically "in the lab"? This presentation outlines a method for such an interactive, visual presentation of calculus designed to encourage critical thinking skills through empirical testing using modern computer software. It will outline a rubric for introducing math topics using software-assisted guided-discovery activities consisting of a sequence of graphical experiments, with two concrete examples to illustrate this rubric in practice using Maple, a popular computer algebra system. (Received September 17, 2008)

1046-Z1-2109 **Terje Hoim*** (thoim@fau.edu), 5353 Parkside Drive, Jupiter, FL 33458, **Eugene Belogay**, 5353 Parkside Dr., Jupiter, FL 33458, and **Eugene T Smith**, 5353 Parkside Dr., Jupiter, FL 33458. *How precise is your calibration? Multiple linear regression and prediction error in Excel.* Preliminary report.

Calibration curves are typically used to determine the unknown concentrations of known compounds in a mixture. In this talk we introduce the calibration problem and compare precision estimates associated with calibration curves involving one or more components. As expected, these problems become much more difficult for mixtures containing more than two components since multiple factors are contributing to the uncertainty. Many chemometric methods used to solve these types of problems require expensive specialized software that is not readily available or familiar to chemistry students. Instead, we compute multiple linear regressions and calculate associated errors using Excel, thus making the topic accessible to undergraduate students. (Received September 17, 2008)

1046-Z1-2116 **Rika Paul*** (rika.paul@famu.edu), Florida A&M University, Department of Mathematics, Jackson Davis Hall, Room 314, Tallahassee, FL 32307, **Rohini Mankee**, Florida A&M University, Department of Mathematics, Jackson Davis Hall, Room 314, Tallahassee, FL 32307, **G. Dale Wesson** (garlen.wesson@famu.edu), Florida A&M Univesity, Biological and Agricultural Systems Eng, 307 North Perry Paige, Tallahassee, FL 32307, and **Desmond Stephens** (desmond.stephens@famu.edu), Florida A&M University, Department of Mathematics, Jackson Davis Hall, Room 314, Tallahassee, FL 32307. *Calculating the void fraction of carbon foam using a tetrahedron model.* Preliminary report.

Carbon foam has become increasingly important due to its low density; high porosity or void fraction ($75 - 90\%$) and high specific thermal conductivity. This study develops a model for the creation of air bubbles in the carbon-foaming process. Currently, reliable and robust models are not readily available through of-the-shelf Computer Aided Design (CAD) software. Our model provides a low cost method that may be useful for testing thermal properties of graphite foam. This model is based on a tetrahedron which has spheres centered at each of its vertices. These spheres represent the bubbles that are produced during a carbon-foaming process. Void fraction calculations are done before and after sphere intersections. For a fixed distance between bubbles (a), sphere radii (R) are allowed to increase. Void fractions are then calculated for three cases: (1) before the spheres intersect, (2) at the point the spheres begin to intersect and (3) after intersection. This calculation is done analytically until $R/a = 0.5$. For $R/a \geq 0.5$, void fractions are calculated using the Monte Carlo Method. The graphical relationship developed here provides a model that can be used to predict the void fraction of the graphite foam for a given ratio R/a. (Received September 18, 2008)

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