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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
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1074	October 14–16, 2011	Lincoln, NE	August 23	Vol 32, No. 4
1075	October 22–23, 2011	Salt Lake City, UT	August 30	Vol 32, No. 4
1076	November 29–December 3, 2011	Port Elizabeth, South Africa	TBA	Vol N, No. A
1077	January 4–7, 2012	Boston, MA	September 22	Vol 33, No. 1
1078	March 3–4, 2012	Honolulu, HI	December 13	Vol 33, No. 2
1079	March 10–11, 2012	Tampa, FL	January 18	Vol 33, No. 2
1080	March 17–18, 2012	Washington, DC	TBA	TBA
1081	March 30–April 1, 2012	Lawrence, KS	February 14	Vol 33, No. 2
1082	September 22–23, 2012	Rochester, NY	TBA	TBA
1083	October 13–14, 2012	New Orleans, LA	August 28	Vol 33, No. 3
1084	October 20–21, 2012	Akron, OH	September 4	Vol 33, No. 4
1085	October 27–28, 2012	Tucson, AZ	September 11	Vol 33, No. 4
1086	January 9–12, 2013	San Diego, CA	TBA	Vol 34, No. 1

WORCESTER, MA, April 9–10, 2011

Abstracts of the 1070th Meeting.

00 ► General

1070-00-37 **Mary-Louise E Timmermans*** (mary-louise.timmermans@yale.edu), Dept. of Geology and Geophysics, Yale University, PO Box 208109, New Haven, CT 06520. *Observing and Characterizing Submesoscale Dynamics in the Upper Arctic Ocean.*

The Arctic Ocean links to sea ice and climate at scales ranging from the large-scale circulation, to mesoscale motions (characterized by horizontal length scales between about 10 and 100 km), to the submesoscale flow field (order 1 km scales). Theoretical, observational and numerical studies on the mid-latitude, ice-free oceans have demonstrated that submesoscale processes play a significant role in upper-ocean lateral and vertical fluxes of heat and mass, and in setting upper-ocean stratification. Here, we present Ice-Tethered Profiler temperature and salinity measurements that show a sub-ice Arctic Ocean mixed layer with a complicated submesoscale structure evolving in the presence of lateral buoyancy gradients (fronts). Surface fronts can become baroclinically unstable to small instabilities (or eddies, with scales on the order of 1 km and growth rates on the order of 1 day) that restratify the mixed layer and enhance buoyancy transport. These submesoscale dynamics are not resolved or parameterized in existing regional and global numerical models of the Arctic – understanding the physics at these scales is necessary for accurate parameterizations, vital for modeling and predicting the state of the Arctic Ocean and climate. (Received February 01, 2011)

1070-00-143 **Shreyas Mandre***, 182 Hope Street, Box D, Providence, RI 02912. *The mechanism of a splash.*

Splashing of droplets, due to its ubiquity in natural and technological phenomena and the captivating beauty of the resulting geometrical forms, has inspired many meticulous studies. Yet, a clear theoretical understanding of the mechanism of splashing on dry surfaces has eluded us for more than a century. It was recently discovered that whether a drop splashes or not depends on the surrounding air pressure. Dynamically, the splash originates

as a thin liquid sheet ejected near the point of impact. But what causes this sheet to be ejected in the first place?

I will present analysis showing that a micron thick layer of surrounding air gets trapped between the drop and the surface and cushions the impact. A rapid deformation of the interface on a microsecond timescale as a result of the cushioning causes the sheet to be ejected before the drop touches the surface. Quantitative predictions can be made about the precise moment and location of sheet ejection, and the thickness and the speed of the sheet. This information allows us to elucidate the mechanism for the splash and map out the parameters promoting splashing. (Received February 07, 2011)

1070-00-155 **Bo Xiong*** (bxiong@conncoll.edu), Connecticut College 5108, 270 Mohegan Avenue, New London, CT 06320, and **Christine Chung** (cchung@conncoll.edu), 270 Mohegan Avenue, New London, CT 06320. *New Lower Bounds for Weighted Completion Time Scheduling.*

We consider the classic scheduling problem of minimizing the total weighted completion time on identical parallel machines when jobs are arriving over time. All the jobs are preemptible. The competitive ratio of an online algorithm is the worst-case ratio of the weighted total completion time of the schedule produced by the algorithm to the weighted total completion time of the optimal offline solution. We prove a new general lower bound of 21/19 for the competitive ratio of any deterministic online algorithm for the above problem. We then focus on analyzing the performance of the natural online algorithm WSRPT (Weighted Shortest Remaining Processing Time First). We prove that the lower bound on the competitive ratio of WSRPT is 22/19. We conjecture that there is a matching upperbound for the competitive ratio of WSRPT, and a proof that WSRPT is 2-competitive is currently a work in progress. (Received February 08, 2011)

1070-00-201 **H. Qin** (qinhz@hotmail.com), Institute of Mathematics, Shandong University of Technology, Zibo, Shandong , Peoples Rep of China, and **Y Lu*** (ylu@bloomu.edu), Department of Mathematics and Computer Scienc, Bloomsburg University, Bloomsburg, PA 17821. *On the representation problems of infinite series with Harmonic numbers.*

For integers p and q, we obtain the representaions of the following extended Euler sums

$$\sum_{n=1}^{\infty}\frac{1}{n^q}\sum_{r=1}^{kn}\frac{1}{r^p},\ \sum_{n=1}^{\infty}\frac{(-1)^{n-1}}{n^q}\sum_{r=1}^{kn}\frac{1}{r^p},\ \sum_{n=1}^{\infty}\frac{1}{n^q}\sum_{r=1}^{kn}\frac{(-1)^{r-1}}{r^p},\sum_{n=1}^{\infty}\frac{(-1)^{n-1}}{n^q}\sum_{r=1}^{kn}\frac{(-1)^{r-1}}{r^p}$$

in terms of the Riemann zeta function and the Hurwitz function when $p+q$ is odd. If $p+q$ is even, these sums are also expressed in terms of the Riemann zeta function. (Received February 11, 2011)

01 ► History and biography

1070-01-9 **Steven H Weintraub*** (shw2@lehigh.edu), Dept. of Mathematics, Lehigh University, Bethlehem, PA 18015-3174. *On Legendre's Work on the Law of Quadratic Reciprocity.*

Legendre was the first to state the law of quadratic reciprocity in the form that we know it, and he was able to prove it in some but not all cases, with the first complete proof being given by Gauss in his *Disquisitiones Arithmeticae* in 1801. In this talk we trace the evolution of Legendre's work on quadratic reciprocity in his four great works on number theory, dating from 1785, 1797, 1808, and 1830 respectively. (Received October 08, 2010)

1070-01-14 **Scott B Guthery*** (sbg@acw.com), 2400 Beacon #208, Chestnut Hill, MA 02467. *C. Haros and the Farey Series.*

C. Haros is frequently credited with first proving the mediant property of the Farey series [Dickson, History of the Theory of Numbers, Volume I, p. 156] but little additional information about Haros is given. Charles Haros was a mathematician in the Bureau du Cadastre, devised new algorithms for computing roots and logarithms and co-edited the French ephemeris. This talk will bring Haros out from behind Farey's and Cauchy's shadows. (Received November 18, 2010)

1070-01-66 **Thomas Drucker*** (druckert@uww.edu), Dept. of Math. and Computer Sciences, University of Wisconsin–Whitewater, 800 West Main Street, Whitewater, WI 53190. *News About the Binomial Theorem in Victorian England.* Preliminary report.

From the Sherlock Holmes stories of Arthur Conan Doyle to the operas of Gilbert and Sullivan the binomial theorem is used as an example of mathematical sophistication. Since there was nothing new about the theorem as an item for research, presumably this reflects a change in the curriculum at schools which authors like Doyle

and Gilbert would have attended. This talk will look at some of the ways in which the binomial theorem would strike a chord in the readers and theatre goers of late nineteenth-century England. (Received January 23, 2011)

1070-01-76 **Francine F. Abeles*** (fabeles@kean.edu). *Martin Gardner's 19th Century Counterpart: Richard A. Proctor.* Preliminary report.

Richard Proctor (1837-1888) and Martin Gardner (1914-2010) had many common interests and talents. As writers, both popularized mathematics and science, Proctor in the British science journal he founded, Knowledge; Gardner in the Games Column of the American journal, Scientific American. As a tribute to Martin Gardner, I will discuss Proctor's efforts to popularize mathematics, a topic about which little is known compared to his popular articles on scientific subjects. (Received January 25, 2011)

1070-01-81 **Amy K Ackerberg-Hastings*** (aackerbe@verizon.net). *The Evolution of Mathematics Teaching Practices, c. 1770-1970.* Preliminary report.

In 1993, Alison King drew a distinction between the "sage on the stage" and the "guide on the side" approaches to the teaching-learning process that has since become so commonplace that it has passed into popular culture. As awareness of the points raised by King and other educational theorists is reduced to a simplistic "sage bad, guide good" dichotomy, casual observers may conclude that the lecture style of teaching has always been utilized in every classroom. However, efforts to foster learning in mathematics classrooms have been more varied and more complex. This paper provides an overview of the techniques employed by mathematics teachers to facilitate and to measure learning both during and after formal class time. The paper also charts some of the major changes in these instructional processes, such as in the structure of textbooks and in the forms established for homework and assessment. In unfolding this account, we will briefly note the historiographical challenges of determining what actually happened during daily routines in mathematics classrooms. (Received January 27, 2011)

1070-01-112 **Christopher Baltus*** (christopher.baltus@oswego.edu), Department of Mathematics, Snygg Hall, SUNY Oswego, Oswego, NY 13126. *Poncelet's Circular Path to Central Collineations.* Preliminary report.

A Central Collineation, a collineation with a line of fixed points, or, equivalently, a point on which all line are fixed – think of Desargues's Theorem – became central in synthetic projective geometry only in Luigi Cremona's Elementi di Geometria Projettiva of 1873. There, figures related by a central collineation were called "homologous." The term and the concept, but not the development, go back to Poncelet's 1822 masterwork. How did Poncelet get to homology? It was his study of circles, a study that began, in earnest, at an elementary level in a Russian prison camp in 1813, and shows his tie to the geometers at the Ecole Polytechnique. We will trace Poncelet's path to homologous figures. (Received February 03, 2011)

1070-01-119 **Peggy Aldrich Kidwell*** (kidwellp@si.edu), MRC671, NMAH, Smithsonian Institution, P.O. Box 37012, Washington, DC 20013-7012. *What's in a Name? Eponyms, Mathematicians, Objects and Museum Collections, from Galileo's Finger to the Bernoulli Box.* Preliminary report.

An eponym is words or phrase formed from a person's name. The names of mathematicians are associated with objects ranging from body parts to personal possessions to computing devices to geometric models of surfaces to teaching apparatus. An historical survey of such usages suggests something about the changing place of mathematics in general culture. This examination draws heavily on the collections of the Smithsonian's National Museum of American History. (Received February 04, 2011)

1070-01-120 **Shai Simonson*** (shai@stonehill.edu), Shai Simonson, Professor of Computer Science, Stonehill College, 320 Washington Street, North Easton, MA 02067. *Levi ben Gershon's Matrix Algebra.* Preliminary report.

Levi ben Gershon (1288-1344), rabbi, philosopher, scientist, and mathematician, lived in Provence and was a well-known scientific figure in his day.

Levi made a number of mathematical contributions in a variety of areas. His major mathematical work Maaseh Hoshev (The Art of Calculation), 1321, is in two parts. The first part is a collection of 68 theorems and proofs in Euclidean style about arithmetic, algebra, sums, proportions, and combinatorics. The second part contains algorithms for calculation and is subdivided into six sections: addition and subtraction; multiplication; sums; combinatorics; division, square roots and cube roots; ratios and proportions. The book ends with a large number of problems illustrating the theory and algorithms.

Levi uses matrix algebra for solving certain problems appearing at the end of Maaseh Hoshev. He implicitly uses matrix algebra when he considers under-determined systems of equations derived from certain problems on proportions. Levi's solutions imply that he has ad-hoc methods to solve particular kinds of systems of n

equations with n variables. However, he has no general method akin to Gaussian elimination for solving an arbitrary system of equations. We review some of these problems. (Received February 04, 2011)

1070-01-122 **Maryam Vulis*** (mlv2007@earthlink.net), 67-67 Burns st, Forest Hills, NY 11375. *Why did AndreiMarkov criticize Sofia Kovalevskaya's proofs?* Preliminary report.

Andrei Markov found "errors" in several proofs published by Sofia Kovalevskaya in her 1889 Memoirs. These gaps were late filled by Lyapunov and Lunev.

Did Markov object Kovalevskaya's arguments for the sake of mathematics or he had other reasons? (Received February 04, 2011)

1070-01-125 **David Lindsay Roberts*** (robertsdl@aol.com). *Simon Newcomb as a Nineteenth Century Mathematics Educator.*

Simon Newcomb was born in 1835 when the structures and interconnections of many educational institutions were still very much in flux in the United States. By 1909, when he died, most of the key institutions were solidifying into close to the forms they retain to the present day. Newcomb followed his mentor Benjamin Peirce into mathematical astronomy, with most of his professional activity conducted for the Nautical Almanac office in Washington, D.C. Newcomb was only a part-time teacher, on the side, but since the institution where he did most of this teaching was the newly founded Johns Hopkins University in Baltimore, of central importance for the history of higher education in the United States, it is well worth giving attention to this facet of his career. Moreover, at the same time that he was teaching at Hopkins, Newcomb was involving himself in the secondary schools, through writing textbooks and journal articles, and serving as chairman of the mathematics subcommittee of the celebrated Committee of Ten of 1892. Examining Newcomb's career thus illuminates the evolution of mathematics in a wide range of late nineteenth century educational institutions. (Received February 05, 2011)

1070-01-147 **Tina R Hartley*** (tina.hartley@usma.edu) and **V Frederick Rickey** (frederick.rickey@usma.edu). *Calculus Books and Curriculum at West Point in the Twentieth Century.*

Calculus books are all the same! How often have you heard that claim? But is it true? Has anyone looked?

We intend to look: to look at the book used today and the book used a century ago at the United States Military Academy, West Point, New York. Then we will look at a few other books published over the intervening years. How are they alike? How do they differ? We will compare their differences and their similarities. We expect similarities, for calculus is calculus. But there are many differences: the level of rigor, the choice of topics, the inclusion of applications. What does this tell us about the intended audience, and the curriculum at the time?

We will also examine how the curriculum has changed over the course of the last century. At the beginning of the 20th century, the West Point entrance exam focused on arithmetic and cadets spent their entire first year studying algebra and geometry before delving into calculus. How has that changed, and why? How have national changes in mathematics education affected the curriculum at West Point? (Received February 07, 2011)

1070-01-150 **Andrew B Perry*** (perryand@gmail.com), 263 Alden St., Springfield, MA 01106. *John Adams's Interest In Mathematics.*

The second American president John Adams's interest in mathematics may not be well-known; nevertheless Adams was passionate about the subject. Adams discussed math in quite a few of his letters and diary entries, and owned an extensive library of mathematical works. Included among these works were sophisticated contemporary works like L'Hospital's Analyse des Infiniment Petits; Adams wrote extensively in the margins of his personal copy of that work. We will discuss the wide ranging scope of Adams's involvement in mathematics in general, drawing from a wide range of historical sources. (Received February 07, 2011)

1070-01-221 **Duncan J Melville*** (dmelville@stlawu.edu), Department of Mathematics, St Lawrence University, Canton, NY 13617. *Mathematics and Magic in Me-Turan.* Preliminary report.

Old Babylonian mathematics, as evidenced by numerous problem texts, went well beyond the needs of administration. Recent work has substantially improved out understanding of the curriculum in schools, especially in Nippur and Ur. However, less attention has been paid to the use of more advanced mathematics outside of the curricular setting, in part because so few mathematical tablets have good archaeological context. In this talk, I will discuss the case of one problem text found with a collection of magical texts in a house in Me-Turan in the Diyala region. (Received February 12, 2011)

1070-01-283 **Paul R Wolfson*** (pwolfson@wcupa.edu), Department of Mathematics, West Chester University, West Chester, PA 19383. *Arnold Sommerfeld's Geometric Model of Relativistic Velocities.* Preliminary report.

Almost immediately after Einstein published his first paper on relativity in 1905, others reworked some of his arguments in more geometrical language. Minkowski's was, of course, the broadest and most successful effort in this direction, but soon several others developed geometrical representations of relativistic velocities. I shall discuss Sommerfeld's spherical representation. (Received February 14, 2011)

1070-01-284 **Jennifer Beineke*** (jbeineke@wnec.edu), Springfield, MA 01119, and **Christopher Hughes** (christopher.hughes@york.ac.uk), York, England. *Great Moments of the Riemann Zeta Function: Served Family-Style.* Preliminary report.

We will explore moments of the Riemann zeta function, beginning with the momentous discoveries of Hardy, Littlewood, and Ingham in the 1920s. We will then discuss other memorable moments that number theorists have encountered as they have worked on open problems related to the Riemann Hypothesis, including related questions for families of L-functions. (Received February 14, 2011)

1070-01-325 **Bruce S. Burdick*** (bburdick@rwu.edu). *Various Observations on Euler's E72.* Preliminary report.

Euler's *Variae observationes circa series infinitas* (E72) considers a variety of infinite sums and products. His first theorem,

$$\frac{1}{3}+\frac{1}{7}+\frac{1}{8}+\frac{1}{15}+\frac{1}{24}+\frac{1}{26}+\frac{1}{31}+\frac{1}{35}+\cdots=1,$$

where the denominators are the whole numbers that are one less than a non-trivial power, he attributes to Golbach, both for its statement and its proof. He then proceeds to prove other theorems in more or less the same manner.

The method of choice for Euler (and presumably Goldbach) involves subtracting infinite quantities from infinite quantities in a way that would no longer be acceptable as a mathematical demonstration. In a recent paper, Edward Sandifer and the speaker gave a modern proof of Euler's Theorem 1. This talk is a follow-up to that paper, and will show that other theorems from E72 can be supplied with proofs that meet the present-day standards of rigor. (Received February 15, 2011)

03 ► Mathematical logic and foundations

1070-03-104 **Rachel Epstein*** (repstein@math.harvard.edu), FAS Department of Mathematics, Harvard University, 1 Oxford St, Cambridge, MA 02138. *Automorphisms of the c.e. sets.*

Let $\mathcal{E}$ be the lattice of computably enumerable (c.e.) sets under set inclusion. We will discuss the history of automorphisms of $\mathcal{E}$ as well as recent results and open problems.

Automorphisms of $\mathcal{E}$ can be used to solve problems regarding definability in $\mathcal{E}$. In particular, we discuss the use of automorphisms to determine which jump classes of degrees are definable. We show that there is a nonlow degree, all of whose elements are automorphic to a low set. This tells us that the nonlow degrees are not definable, despite all other upward closed jump classes being definable. It also leads to the question of characterizing which sets are automorphic to low sets. (Received February 02, 2011)

1070-03-115 **Kerry Ojakian*** (kerryojakian@gmail.com) and **Manuel Campagnolo**. *Characterizing computable analysis with differential equations.*

I will present joint work with Manuel L. Campagnolo. The functions of Computable Analysis are defined by enhancing the capacities of normal Turing Machines to deal with real number inputs. We consider characterizations of these functions using function algebras, known as Real Recursive Functions (Moore 1996). The function algebras are defined by specifying some basic functions, and closing these functions under composition and other operations (such as setting up a differential equation with functions in the algebra and putting the solution in the algebra). Bournez and Hainry (2006) used a function algebra to characterize the twice continuously differentiable functions of Computable Analysis, restricted to certain compact domains. I will speak about recent submitted work that improves this, finding three characterizations of Computable Analysis, removing the restriction to twice continuously differentiable and allowing unbounded domains. Furthermore, the recent proof uses our "method of approximation" from our earlier work, providing further evidence of our claim that this technique should have wide applicability in work of this kind. (Received February 03, 2011)

1070-03-179 **Paola D'Aquino**, **Julia Knight** and **Karen Lange***, Mathematics Department, 255 Hurley, Notre Dame, IN 46556. *Computability of integer parts.*

An *integer part* of a real closed field R is a discrete ordered subring I containing 1 such that for all $r \in R$ there exists a unique $i \in I$ with $i \leq r < i + 1$. Mourgues and Ressayre showed that every real closed field R has an integer part. For a countable real closed field R, we previously showed that the integer part obtained by the procedure of Mourgues and Ressayre is $\Delta^0_{\omega^\omega}(R)$. We would like to know whether there exists a construction that yields a computationally simpler integer part, perhaps one that is $\Delta^0_2(R)$. All integer parts are *Z-rings*, discretely ordered rings that have the euclidean algorithm for dividing by integers. By a result of Wilkie, any Z-ring can be extended to an integer part for *some* real closed field. We show that we can compute a maximal Z-ring I for any real closed field R that is $\Delta^0_2(R)$, and we then examine whether this I must serve as an integer part for R. We also show that certain subclasses of $\Delta^0_2(R)$ are not sufficient to contain integer parts for a real closed field R. (Received February 10, 2011)

1070-03-225 **Cora Waterman*** (cwaterma@smith.edu), Box 8688, Smith College, Northampton, MA 01063, and **Samantha Lowe**, **Elizabeth Cowdery** and **Sarah Costrell**. *A Paracomplete Logic and the Sortanatural Numbers.* Preliminary report.

We describe a logic with infinitely many truth values in which statements may be neither true nor false. We derive properties of the logic, such as the failure of the Law of the Excluded Middle, and show that it resolves a number of paradoxes.

We then apply the principles of the logic to arithmetic to construct a number system with many curious properties and a provably strong but provably limited resemblance to the natural numbers. (Received February 12, 2011)

1070-03-245 **Rebecca M. Steiner*** (rsteiner@gc.cuny.edu). *The Art of Galois Theory in Computable Field Theory.*

Galois theory has a way of taking existential-type questions and turning them into questions which can be answered by checking only finitely many things. As a familiar example, to determine whether a polynomial f(X) in F[X] can be solved by radicals, instead of looking through the field F for elements x expressible by radicals for which f(x)=0, we only need to check that a particular phenomenon happens for each divisor of the size of the Galois group of f(X) over the rationals. Here we present new examples of how Galois theory assists us in proving computability-theoretic results. (Received February 13, 2011)

1070-03-253 **Rodney G. Downey** (rod.downey@msor.vuw.ac.nz), **Asher M. Kach*** (asher.kach@uconn.edu), **Steffen Lempp** (lempp@math.wisc.edu) and **Daniel Turetsky** (dan.turetsky@msor.vuw.ac.nz). *Computable Categoricity and Relative Computable Categoricity.*

Though the notions of computable categoricity and relative computable categoricity are rather similar, there are well-known examples of structures that show these notions do not coincide. In this talk, we illustrate situations where these notions converge and situations where these notions (their relativizations) diverge dramatically. (Received February 14, 2011)

1070-03-262 **Marcia J. Groszek*** (marcia.groszek@dartmouth.edu), Dartmouth College, 6188 Kemeny Hall, Hanover, NH 03755-3551. *Ramsey Properties of Partial Orderings and Arithmetic Comprehension.*

A partial ordering $(\mathbb{P}, \leq_{\mathbb{P}})$ has the Ramsey property for pairs if, for every coloring of ordered pairs $p \leq_{\mathbb{P}} q$ in finitely many colors, there is a homogeneous subordering isomorphic to $(\mathbb{P}, \leq_{\mathbb{P}})$. In "Reverse mathematics, computability, and partitions of trees," (J. Symbolic Logic 74 (2009), no. 1, 201-215), Chubb, Hirst, and McNicholl ask, "Is there a Ramsey theorem on some class of partial orders where the theorem for pairs is equivalent to ACA_0 [arithmetic comprehension]?" We show there is a primitive recursive partial ordering $\mathbb{P}$ such that, over the base theory RCA_0, the statement "$\mathbb{P}$ has the Ramsey theory for pairs" is equivalent to ACA_0. (Received February 14, 2011)

1070-03-270 **Rebecca Weber*** (rweber@math.dartmouth.edu), 6188 Kemeny Hall, Hanover, NH 03755. *Sets automorphic to low sets.* Preliminary report.

The non-low degrees are the only upward-closed jump class that is not degree invariant in the computably enumerable sets, as shown by Rachel Epstein. I will survey joint work in progress with Peter Cholak on a property of computably enumerable sets sufficient, and possibly necessary, to guarantee automorphism to some low c.e. set; the property is adapted from one of Maass. We distinguish the Δ^0_3-automorphic case from the

general case, though it is open whether automorphisms of higher arithmetic complexity change the situation. (Received February 14, 2011)

1070-03-288 **Johanna N.Y. Franklin*** (johannaf@gauss.dartmouth.edu), Department of Mathematics, 6188 Kemeny Hall, Dartmouth College, Hanover, NH 03755, and **Keng Meng Ng**. *ω-r.e. randomness.*

Previously, we strengthened the notion of Martin-Löf randomness by requiring that a random real avoid not only all Martin-Löf tests but all tests whose components are n-r.e. sets of open sets for a fixed n. Now we extend this notion to that of f-r.e. randomness for any recursive function f by requiring that the k^{th} component of a test be an $f(k)$-r.e. set of open sets for each k. We further say that a real is ω-r.e. random if it is f-r.e. random for every recursive f. Here, we present some basic results on ω-r.e. and f-r.e. randomness and describe the relationship of the former to other strong randomness notions. (Received February 14, 2011)

1070-03-312 **Carl Jockusch, Jr.**, **Bart Kastermans**, **Steffen Lempp**, **Manuel Lerman** and **Reed Solomon***, Department of Mathematics, 196 Auditorium Road, University of Connecticut, U-3009, Storrs, CT 06269. *Stability and posets.*

Hirschfeldt and Shore introduced a notion of stability for infinite posets. In this talk, we discuss a weaker notion of stability and compare the complexity of chains and antichains in stable and weakly stable posets. (Received February 15, 2011)

05 ► Combinatorics

1070-05-28 **Glenn D. Appleby*** (gappleby@scu.edu) and **Tamsen Whitehead**. *Products of Littlewood-Richardson Fillings and Flows on Honeycombs.*

The Littlewood-Richardson (or "LR") coefficient $c_{\mu\nu}^{\lambda}$ for partitions μ, ν and λ counts "fillings" $\{k_{ij}\}$ of the skew shape λ/μ with content ν. King, Tollu and Toumazet found conditions under which LR coefficients factor as a product of coefficients of sub-partitions. Here we present a *product* on LR fillings themselves which recovers the factorizations of King, et al, but is defined more generally for arbitrary fillings. Given two LR fillings $\{k_{ij}\}$ of shape λ/μ of content ν and $\{k'_{ij}\}$ of shape λ'/μ' of content ν', our algorithm produces a third filling of shape λ''/μ'' of content ν'', where, μ'' is obtained by from the parts of μ and μ', etc. We show that this product on LR fillings is the "right" one by proving it recovers the filling obtained by the *overlay* operation of two honeycombs (combinatorial invariants equivalent to LR fillings and of recent interest in representation theory). To do this, we develop a novel *flow* on a honeycomb, and show how our combinatorial algorithm mirrors rectifying flows on the overlay of two honeycombs. Questions on the factored structure of fillings will also be discussed. (Received December 15, 2010)

1070-05-40 **John M. Jones*** (jj_jones@my.uri.edu), 89 Minot St., Falmouth, MA 02540. *A Method for Developing Triple Whist Designs.*

This presentation will introduce the combinatorial structure known as a whist tournament design. In Particular, a specialization of whist designs, a triple whist tournament will be discussed. Part of the presentation will focus on the origins of this project and what it has evolved into. An algorithm that generates whist structures of certain parameters that has been developed through this project will be discussed. This project began in 2008 and continues through the present. (Received February 13, 2011)

1070-05-62 **Andrew E Crites*** (acrites@uw.edu), Department of Mathematics, University of Washington, Box 354350, Seattle, WA 98195-4350, and **Sara Billey** (billey@uw.edu), Department of Mathematics, University of Washington, Box 354350, Seattle, WA 98195-4350. *Pattern characterization of rationally smooth affine Schubert varieties of type A.*

Schubert varieties in finite dimensional flag manifolds G/P are a well-studied family of projective varieties indexed by elements of the corresponding Weyl group W . In particular, there are many tests for smoothness and rational smoothness of these varieties. One key result due to Lakshmibai-Sandhya is that in type A the smooth Schubert varieties are precisely those that are indexed by permutations that avoid the patterns 4231 and 3412. Recently, there has been a flurry of research related to the infinite dimensional analogs of flag manifolds corresponding with G being a Kac-Moody group and W being an affine Weyl group or parabolic quotient. In this paper we study the case when W is the affine Weyl group of type A or the affine permutations. We develop the notion of pattern avoidance for affine permutations. Our main result is a characterization of the rationally smooth

Schubert varieties corresponding to affine permutations in terms of the patterns 4231 and 3412 and the twisted spiral permutations. (Received January 21, 2011)

1070-05-69 **Matjaz Konvalinka*** (matjaz.konvalinka@gmail.com). *Skew quantum Murnaghan-Nakayama rule.*

We extend recent results of Assaf and McNamara on skew Pieri rule and skew Murnaghan-Nakayama rule to a more general identity, which gives an elegant expansion of the product of a skew Schur function with a quantum power sum function in terms of skew Schur functions. We give two proofs, one completely bijective in the spirit of Assaf-McNamara's original proof, and one via Lam-Lauve-Sotille's skew Littlewood-Richardson rule. Some conjectures for skew rules for Hall-Littlewood polynomials will also be presented. (Received January 24, 2011)

1070-05-71 **Christopher R H Hanusa*** (Christopher.Hanusa@qc.cuny.edu), Department of Mathematics, Kiely 237, Queens College, CUNY, 65-30 Kissena Blvd., Flushing, NY 11367, and **Brant C Jones** (brant@math.jmu.edu), Department of Mathematics and Statistics, MSC 1911, James Madison University, Harrisonburg, VA 22807. *The enumeration of fully commutative affine permutations.*

We give a generating function for the fully commutative affine permutations enumerated by rank and Coxeter length, extending formulas due to Stembridge and Barcucci–Del Lungo–Pergola–Pinzani. For fixed rank, the length generating functions have coefficients that are periodic with period dividing the rank. In the course of proving these formulas, we obtain results that elucidate the structure of the fully commutative affine permutations. (Received January 24, 2011)

1070-05-94 **Gregory S. Warrington*** (Gregory.Warrington@uvm.edu), Dept. of Mathematics & Statistics, 16 Colchester Ave., Burlington, VT 05401, and **Nicholas Loehr**. *Quasisymmetric expansions of Schur plethysms.*

Let s_μ denote a Schur symmetric function and Q_α a fundamental quasisymmetric function. Explicit combinatorial formulas are developed for the fundamental quasisymmetric expansions of the plethysms $s_\mu[s_\nu]$ and $s_\mu[Q_\alpha]$, as well as for related plethysms defined by inequality conditions. The key tools for obtaining these expansions are new standardization and reading word constructions for matrices. (Received February 01, 2011)

1070-05-106 **Jonathan Novak*** (j2novak@uwaterloo.ca), Department of Combinatorics and Optimization, University of Waterloo, 200 University Avenue West, Waterloo, Ontario N2L 3G1, Canada. *Tracking the Jucys-Murphy Specialization.*

Specializations of the algebra of symmetric functions can often be used to clarify our understanding of complicated relationships between quantities of combinatorial interest. This is similar in spirit to the way in which representations of compact Lie groups can unify our understanding of special functions. I will discuss a specialization which maps the algebra of symmetric functions onto the center of the symmetric group algebra, and the problem of tracking the images of familiar symmetric functions (elementary, complete, power sum, monomial, etc.) under this specialization. This problem, which turns out to be relevant in a wide variety of contexts such as matrix integrals and Gromov-Witten theory, can be addressed using tools from both algebraic and enumerative combinatorics. (Received February 02, 2011)

1070-05-114 **Travis Schedler*** (trasched@gmail.com) and **Qendrim R. Gashi**. *Normality and quadraticity for special ample line bundles on toric varieties arising from root systems.*

We prove that special ample line bundles on toric varieties arising from root systems are projectively normal. Here special means that the bundle is torus-equivariant, and the character of the line bundle that corresponds to a maximal Weyl chamber is dominant with respect to that chamber. Moreover, we prove that the associated semigroup algebra is quadratic. (Received February 03, 2011)

1070-05-128 **Priyavrat Deshpande*** (pdeshpan@uwo.ca), Mathematics Department, The University of Western Ontario, London, Ontario N6A5B7, Canada. *Complexified Arrangement of Pseudo-hyperplanes.*

To every realizable oriented matroid there corresponds an arrangement of real hyperplanes. The homeomorphism type of the complexified complement of such an arrangement is completely determined by the oriented matroid. The Salvetti complex, a finite cell complex defined using the oriented matroid, is the spine of this complement.

The aim of this talk to extend this correspondence to non-realizable oriented matroids. We generalize the complexification process in order to obtain a subset of a twice dimensional space that has the homotopy type of the associated Salvetti complex. (Received February 06, 2011)

1070-05-130 **Drew Armstrong**, **Christian Stump*** (christian.stump@lacim.ca) and **Hugh Thomas**. *A uniform bijection between nonnesting and noncrossing partitions.*

In 2007, D.I. Panyushev defined a remarkable map on the set of nonnesting partitions (antichains in the root poset of a finite Weyl group). We identify Panyushev's map with the Kreweras complement on the set of noncrossing partitions, and hence construct the first uniform bijection between nonnesting and noncrossing partitions. Unfortunately, the proof that our construction is well-defined is case-by-case, using a computer in the exceptional types. Fortunately, the proof involves new and interesting combinatorics in the classical types. As consequences, we prove some conjectural properties of the Panyushev map, and we prove two cyclic sieving phenomena conjectured by D. Bessis and V. Reiner. (Received February 06, 2011)

1070-05-144 **Jacob Harper*** (jacob.harper@colorado.edu). *Homology representations arising from a hypersimplex.*

I will start by describing a hypersimplex and its association with Coxeter groups. Then I will construct a matching on the face lattice of a hypersimplex and use discrete Morse theory to classify all subcomplexes whose reduced homology groups are concentrated in a single degree. These homology groups support a natural action of the symmetric group and I will finish my talk by describing the characters that this action produces. (Received February 07, 2011)

1070-05-148 **Drew Armstrong*** (armstrong@math.miami.edu), 1365 Memorial Dr, Ungar 515, Coral Gables, FL 33146, and **Victor Reiner** and **Brendon Rhoades**. *Parking Modules.*

I will mention parking functions (we love them!) which Haiman describes as "the action of a Weyl group W on the quotient Q/hQ of its root lattice Q". I will define two flavors (which are **new** in one sense; **not** in another), called nonnesting and noncrossing. The NN and NC parking functions are the same (for Weyl groups) but (as usual) we don't know why. Here's a thing: The NC parking functions exist for **noncrystallographic** types! There are $(10+1)^3 = 1331$ parking functions of type H_3, which I can show to you. I will share the applause (if any) with Vic Reiner and Brendon Rhoades. (Received February 07, 2011)

1070-05-158 **Cristian Lenart*** (lenart@albany.edu), Department of Mathematics, State University of New York at Albany, 1400 Washington Avenue, Albany, NY 12222, and **Anne Schilling** (anne@math.ucdavis.edu), Department of Mathematics, University of California, One Shields Avenue, Davis, CA 95616. *The energy function on crystals via the alcove model.* Preliminary report.

Crystals are colored directed graphs encoding quantum group representations when the quantum parameter goes to 0. Crystals for affine Kac-Moody algebras are endowed with a grading given by the energy function, which also appears in the theory of exactly solvable lattice models. In Lie type A, Lascoux and Schützenberger defined a statistic called charge (on the corresponding crystals), which is easier to compute. Nakayashiki and Yamada showed that the charge coincides with the energy; their proof is based on intricate combinatorics of Young tableaux. We will present a transparent approach to this problem, which is based on the alcove model in the representation theory of Lie algebras, and is also connected to the theory of Macdonald polynomials. Then we will discuss the generalization to other classical types, in particular the construction of a type C charge. Part of this work is joint with Anne Schilling. (Received February 08, 2011)

1070-05-182 **Luis G. Serrano*** (serrano@lacim.ca), Laboratoire de Combinatoire et d'Informatique, Universite du Quebec a Montreal, CP 8888, Succ. Centre-ville, Montreal, Quebec H2X 3Y7, Canada, and **Christian Stump** (christian.stump@lacim.ca), Laboratoire de Combinatoire et d'Informatique, Universite du Quebec a Montreal, CP 8888, Succ. Centre-ville, Montreal, Quebec H2X 3Y7. *k-triangulations, k-fans of Dyck paths, and pipe dreams.*

We present a bijection between k-triangulations of an n-gon and k-fans of Dyck paths (both generalizations of well known Catalan objects). This bijection goes through widely used objects in combinatorics such as pipe dreams and flagged tableaux. We discuss a generalization of the associahedron obtained in this manner, and study some of its properties. If time permits, we will mention a conjectured cyclic sieving phenomenon. This is based on arXiv:1009.4690 (Received February 10, 2011)

1070-05-187 **Zachary Strider McGregor-Dorsey*** (mcgregoz@colorado.edu). *Full Heaps and Minuscule Posets.*

A heap is a kind of poset with each element assigned a label taken from the vertices of an underlying graph and with each relation subject to certain restrictions derived from the edges of the underlying graph. J. Stembridge showed that the minuscule elements of a Weyl group are in correspondence with the set of heaps over the group's

Dynkin diagram, subject to certain restrictions. For finite Weyl groups, the 'largest' of these heaps are minuscule posets. For affine Weyl groups, no such 'largest' heap can exist because the groups are infinite. However, R. Green has developed the theory of full heaps, which are poset constructions similar to minuscule posets, albeit infinite. This presentation will discuss several properties full heaps and minuscule posets share and other aspects in which they differ. (Received February 10, 2011)

1070-05-191 **Daniel Daly*** (ddaly@semo.edu), 1 University Plaza, MS 6700, Cape Girardeau, MO 63701. *Enumerating permutations containing few copies of 321 and 3412.*

We will discuss the use of reduced decompositions in the enumeration of permutations containing few copies of 321 and 3412. The connections between reduced decompositions and permutation patterns have been studied by Tenner, Stanley, Billey and Jockush among others. Permutations avoiding both 321 and 3412 have been successfully enumerated by West, Fan and others. We will discuss results involving the enumeration of permutations containing either one or two copies of 321 and avoiding 3412 or vice versa. (Received February 10, 2011)

1070-05-193 **Kara B Greenfield*** (kgreenfield@wpi.edu). *Fixing Numbers of Trees.*

The fixing number of a graph, G, is the smallest number, k, such that there is a set of k vertices in V(G), such that assigning a unique label to each of those k vertices removes all but the trivial automorphism. While most general graphs have fixing number 0, most trees have larger fixing numbers, making them a very interesting type of graph to study in this context. We will discuss the efficient computation of the fixing numbers of trees and of specific types of trees, particularly examining the computational advantages that can be gained because of the prior knowledge of the graph type. Additionally, we will examine the distribution of fixing numbers of general trees, homeomorphically irreducible trees, and rooted trees. (Received February 10, 2011)

1070-05-195 **Christopher R. H. Hanusa** and **Brant C. Jones*** (brant@math.jmu.edu). *Abacus models for parabolic quotients of affine Weyl groups.* Preliminary report.

The cosets of a finite Weyl group inside the corresponding affine Weyl group have remarkable structure with connections to various objects in algebra and geometry. The abacus is a versatile combinatorial model for these cosets that originates in the work of James and Kerber for the symmetric group. We describe generalizations of this model for the affine types $\widetilde{B}$, $\widetilde{C}$ and $\widetilde{D}$. (Received February 11, 2011)

1070-05-204 **Aba Mbirika*** (ambirika@bowdoin.edu). *Combinatorial commutative algebra meets an object from geometric representation theory.*

The well-studied Springer variety is at the heart of algebraic geometry and representation theory. Hessenberg varieties are an important generalization of the Springer varieties to a two-parameter family of varieties. Although Hessenberg varieties arise in many contexts, little is known about their cohomology rings. We employ techniques of both combinatorics and commutative algebra to study these rings using polynomial quotient rings. Analogous to the Springer setting and the so-called Tanisaki ideals, we build ideals of what we call truncated symmetric functions generalizing the Tanisaki ideals. The quotient we build successfully describes the Betti numbers of the cohomology ring of regular nilpotent Hessenberg varieties. In their own right, however, these ideals of truncated symmetric functions are very interesting. We give an alternate description of these ideals via a Gröbner basis presentation. Along the way we prove a remarkable connection between elementary and complete truncated symmetric functions. (Received February 11, 2011)

1070-05-206 **Tom Denton*** (sdenton@math.ucdavis.edu), 5 Baggins End, Davis, CA 95616. *Applications of Zero-Hecke Algebras.*

Recently the combinatorial nature of the representation theory of zero-Hecke algebras and related objects have been explored. I will discuss applications of these ideas in addressing and generalizing some well-known problems in algebraic combinatorics, such as pattern avoidance. (Received February 11, 2011)

1070-05-208 **Gregory S. Warrington***, Department of Mathematics & Statistics, University of Vermont, 16 Colchester Ave., Burlington, VT 05401. *On the mu-coefficients of Kazhdan-Lusztig polynomials.* Preliminary report.

The Kazhdan-Lusztig polynomials satisfy a simple recursive relation. However, the combinatorics of these polynomials are quite complicated. Due to their importance in the recursion, the mu-coefficients (i.e., the coefficients of the terms of highest possible degree) are of particular interest. In this talk we consider the relation between these coefficients and "crosshatch" intervals for Kazhdan-Lusztig polynomials associated to the symmetric group. (Received February 11, 2011)

1070-05-218 **Stefan Forcey*** (sf34@uakron.edu), **Aaron Lauve** and **Frank Sottile**. *Indelible grafting: species and graded Hopf operads.*

Composition of species is a familiar monoidal product. Monoids with respect to composition are discrete or combinatorial operads. We find that when the structures of such an operad can be split then it immediately spans a Hopf algebra.

On top of that, the algebraic features are inherited by any species composition of such an operad with another that projects to it. Examples include the results of grafting and splitting binary trees, sometimes combed and with or without levels. It is just such species whose structures we draw by refusing to erase grafts. Those pictures are the vertices of new polytopes, extending families of spaces familiar from the axioms of homotopy maps of A_∞ spaces. Several examples give rise to well known algebras, others are new, and there is a bounty of possibilities for future investigation. (Received February 12, 2011)

1070-05-219 **Greta Panova*** (panova@math.harvard.edu), One Oxford St Rm 431h, Cambridge, MA 02138. *Tableaux and plane partitions of truncated shapes.*

We consider a new kind of straight and shifted plane partitions/Young tableaux — ones whose diagrams are no longer of partition shape, but rather Young diagrams with boxes erased from their upper right ends. We find formulas for the number of standard tableaux in certain cases, namely a shifted staircase without the box in its upper right corner and a rectangle with a staircase removed from the upper right end. The proofs involve interpretations and formulas for sums of restricted Schur functions and their specializations, some RSK tricks and residue calculus. (Received February 12, 2011)

1070-05-228 **Kevin Purbhoo***, Combinatorics & Optimization, University of Waterloo, 200 University Ave. W, Waterloo, Ontario , Canada. *Wronskians and the Cyclic Sieving Phenomenon.*

In 2008, Rhoades proved a cyclic sieving theorem for promotion on standard Young tableaux of rectangular shape: the number of fixed points of any power of promotion is obtained by evaluating the q-analogue of the hook length formula at a root of unity. Although this is a combinatorial statement (and can be reformulated as a problem of establishing a bijection between two sets), there is no known direct combinatorial proof of this statement: Rhoades' proof is representation-theoretic in nature.

I will talk about some new results concerning the geometry of the inverse Wronskian problem, which are motivated by questions in real algebraic geometry. Remarkably, these results give a new geometric proof of the cyclic sieving theorem for promotion. (Received February 13, 2011)

1070-05-237 **Brent G Pohlmann*** (aquaman55@gmail.com), 58B Alvarado Street, San Francisco, CA 94110. *A Riemann–Roch Theorem For Acyclic Heaps Of Pieces.* Preliminary report.

In a previous paper we introduced the notions of boundary vertex, linear equivalence and effective boundary vertex in the context of Viennot's heaps of pieces. These definitions were inspired in part by Baker and Norine's graph-theoretic analogue of the classical Riemann–Roch theorem. In light of these similarities it seems natural to pursue a Riemann–Roch theorem for acyclic heaps and pieces. In this paper, we attempt to show that the abstract Riemann–Roch criterion from Baker and Norine's paper holds for acyclic heaps of pieces. (Received February 13, 2011)

1070-05-240 **Hugh Denoncourt*** (Hugh.Denoncourt@Colorado.edu), MN. *A refinement of weak order intervals into distributive lattices.*

The focus of this talk is arbitrary intervals in the weak Bruhat order. One can show that the set of Lehmer codes of permutations in an interval forms a distributive lattice. Furthermore, the rank-generating function of this distributive lattice matches that of the interval. We demonstrate the construction of a poset whose order ideals form a distributive lattice isomorphic to the set of Lehmer codes of the interval. (Received February 13, 2011)

1070-05-243 **Sarah K Mason*** (masonsk@wfu.edu), Winston Salem, NC 27106, and **Jeffrey Remmel**. *The omega involution on quasisymmetric functions.*

The classical omega involution on symmetric functions sends a Schur function indexed by a partition to the Schur function indexed by the conjugate partition. A refinement of this involution to quasisymmetric functions is defined on certain quasisymmetric function bases by Ehrenborg and Malvenuto-Reutenauer. We describe this involution on the quasisymmetric Schur function basis and use this to obtain skew quasisymmetric Schur functions. (Received February 13, 2011)

1070-05-244 **Shih-Wei Chao*** (schao@clemson.edu) and **Matthew Macauley** (macaule@clemson.edu). *The cyclically fully commutative elements in a Coxeter group.* Preliminary report.

In this talk, we will introduce the cyclically fully commutative (CFC) elements in a Coxeter group. Roughly speaking, these are the elements whose reduced expressions when written as cyclic words, avoid long braid relations. We will show how these are easily enumerated in any Coxeter group, and discuss some interesting combinatorial problems. In particular, we are looking at how to describe the CFC elements via generalized pattern avoidance, and as subsets of non-crossing and/or non-nesting partitions. Finally, we will discuss preliminary findings on enumerating the CFC affine permutations by length. (Received February 13, 2011)

1070-05-275 **Mark A Skandera***, Lehigh University Mathematics Department, Christmas-Saucon Hall, 14 East Packer Avenue, Bethlehem, PA 18015, and **Brittany Shelton** and **Sam Clearman**. *Path tableaux and combinatorial interpretations for S_n-class functions.*

Around 1991, Goulden-Jackson, Greene, Haiman, Stanley, and Stembridge studied the evaluation of S_n class functions on generating functions in $Z[S_n]$ which are products of Kazhdan-Lusztig basis elements. This led Stembridge to prove algebraically that irreducible S_n-characters evaluate nonnegatively on the $Z[S_n]$ generating functions, and to conjecture that related "monomial virtual characters" have the same property. We point out that the analogous result for induced sign characters, which follows from the earlier Littlewood-Merris-Watkins identity, has a nice combinatorial interpretation. Using this interpretation, we combinatorially prove special cases of the Stembridge result and conjecture. We also conjecture a combinatorial interpretation for a known q-analog of the Littlewood-Merris-Watkins identity, and relate this to Haiman's q-analogs of Stembridge's result and conjecture. (Received February 14, 2011)

1070-05-286 **Joseph Cormier*** (jncormier@plymouth.edu), **Dana C. Ernst** (dcernst@plymouth.edu), **Zachariah Goldenberg** (zngoldenberg@plymouth.edu), **Jessica Kelly** (jnkelly@plymouth.edu) and **Christopher Malbon** (clmalbon@plymouth.edu). *Classification of the T-avoiding permutations and generalizations to other Coxeter groups.*

We say that a permutation w has property T if there exists i such that either $w(i) > w(i+1), w(i+2)$ or $w(i+2) < w(i), w(i+1)$. A permutation w is T-avoiding if neither w or w^{-1} have property T. In this talk, we will classify the T-avoiding permutations, as well as discuss their connection to 321- and 3412-avoiding permutations and cyclically fully commutative elements of Coxeter groups of type A. Our result is a reformulation of previous results, but with a simpler proof. In addition, we will discuss possible generalizations to other Coxeter groups. (Received February 14, 2011)

1070-05-296 **Karola Meszaros*** (karola@math.mit.edu) and **Alexander Postnikov**. *Branched polymers and hyperplane arrangements.*

Branched polymers are certain configurations of nonoverlapping disks in the plane. In 2003 Brydges and Imbrie discovered some remarkable formulas for the volumes of configuration spaces of branched polymers. These formulas mysteriously involve combinatorial numbers like $(n-1)!$. We introduce branched polymers arising from any central hyperplane arrangement $\mathcal{A}$ and express the volume of the resulting configuration space through the characteristic polynomial of $\mathcal{A}$. (Received February 15, 2011)

1070-05-305 **Saúl A. Blanco*** (sabr@math.cornell.edu), Department of Mathematics, Cornell University, Ithaca, NY 14853. *Flip algorithm: separating Bruhat paths into nice pieces.* Preliminary report.

Let (W, S) be a Coxeter system and $T = \{wsw^{-1} : s \in S, w \in W\}$ be the corresponding set of reflections. Furthermore, let $u, v \in W$ with $u \leq v$ in Bruhat order. The Bruhat graph $B(u, v)$ of $[u, v]$ is a directed graph whose vertices are elements of W and whose edges correspond to elements of T. The longest u-v paths of $B(u, v)$ are well understood, but little is known about the other u-v paths. We present an algorithm that separates the paths of a fixed length in $B(u, v)$ into subsets, so that each subset has properties that resemble those of the set of longest u-v paths. (Received February 15, 2011)

11 ► Number theory

1070-11-6 **Byungchul Cha*** (cha@muhlenberg.edu), 2400 Chew st, Allentown, PA 18104. *Partial sum of the Möbius function in function fields.*

We study the growth rate of the summatory function of the Möbius function in the context of an algebraic curve over a finite field. Our work shows a strong resemblance to its number field counterpart, which was proved by Ng

in 2004. We find an expression for a bound of the summatory function, which becomes sharp when the zeta zeros of the curve satisfy a certain linear independence property. Then, we consider a certain geometric average of such bound in a family of hyperelliptic curves, using Katz and Sarnak's reformulation of the equidistribution theorem of Deligne. Lastly, we study an asymptotic behavior of this average as the family gets larger by evaluating the average values of powers of characteristic polynomials of random unitary symplectic matrices. (Received September 19, 2010)

1070-11-52 **Joseph H Silverman*** (jhs@math.brown.edu), Mathematics Department - Box 1917, Brown University, Providence, RI 02912. *Number Theory and Dynamical Systems: A Survey.*

Recent years have seen a flourishing new field in which one studies dynamical analogues of classical results and conjectures in algebraic number theory and arithmetic geometry. In this talk I will give a survey of fundamental problems and recent results in arithmetic dynamics. To give a flavor of the talk, I mention two examples. The first is the study of the arithmetic properties of (pre)periodic points. Preperiodic points are dynamical analogues of torsion points on abelian varieties. There are many interesting arithmetic questions that one can ask about preperiodic points, including the problem of uniform boundedness, equidistribution in various topologies, and arithmetic properties of the towers of number fields that they generate. A second topic, which is also an area of much current research, is to describe the intersection of a subvariety with a special set of points such as the set of preperiodic points, sets of points of small height, or orbits of non-preperiodic points. (Received January 11, 2011)

1070-11-77 **Yinghui Wang*** (yinghui@mit.edu), 362 Memorial Dr, Cambridge, MA 02139, and **Steven J Miller**. *From Fibonacci numbers to Central Limit Type Theorems.*

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

Our method generalizes to many other problems. For example, every integer is uniquely a sum of the $\pm F_n$'s, such that every two terms of the same (opposite) sign differ in index by at least 4 (3). We prove the distribution of the numbers of positive and negative summands converges to a bivariate normal with correlation $-(21-2\varphi)/(29+2\varphi) \approx -0.551$. (Received January 26, 2011)

1070-11-84 **Helen G. Grundman*** (grundman@brynmawr.edu), 101 N. Merion Ave., Bryn Mawr, PA 19010, and **Daniel P. Wisniewski** (Daniel.Wisniewski@desales.edu), 2755 Station Avenue, Center Valley, PA 18034. *On Tetranomial Thue Equations.* Preliminary report.

Let $F(x,y) = ax^n + rx^m y^{n-m} - sx^k y^{n-k} + ty^n$ be an irreducible polynomial with integer coefficients and exactly four non-zero terms, $n > m > k > 0$. We consider the problem of bounding the number of integer solutions to the equation $|F(x,y)| = 1$, with the added assumptions that $\left|\frac{rm}{an}\right| < .99$ and $\left|\frac{s(n-k)}{tn}\right| < .99$.

In this talk, I will discuss our methods, adapted from those of Emery Thomas for the cubic case, and present our explicit numerical bounds on the number of solutions. (Received January 30, 2011)

1070-11-86 **Robert L. Benedetto*** (rlb@math.amherst.edu). *Some Open Problems in Non-archimedean Dynamics.*

Let K be an algebraically closed field that is complete with respect to a non-archimedean absolute value $|\cdot|_v$. Given a rational function $f(z) \in K(z)$ of degree at least two, denote by f^n the composition of f with itself n times, and consider the action of f^n both on the classical projective line and on the Berkovich projective line over K.

In the past fifteen years, much has been proven about such non-archimedean dynamical systems, including a classification of dynamics on the Fatou set of f and the existence of an f-invariant measure on the (Berkovich space) Julia set of f. However, many questions remain unanswered. In this talk, we will give a brief background on known results in the field and present a number of open questions. (Received January 31, 2011)

1070-11-87 **Jean Bourgain** and **Alex Kontorovich***, 3-120 Math Tower, Stony Brook University, Stony Brook, NY 11794. *On Zaremba's Conjecture.*

Zaremba's 1972 conjecture states that for every integer q, there is some coprime p, such that the rational p/q has continued fraction expansion with uniformly bounded convergents. It has applications to the theory of good lattice points in numerical integration, and the linear congruential method for pseudo-random number generation. We will present recent progress on this problem. (Received January 31, 2011)

1070-11-100 **Ivan E. Horozov*** (ivan.horozov@uni-tuebingen.de), Institute of Mathematics, University of Tuebingen, Auf der Morgenstelle 10, 72076 Tuebingen, Germany. *Multiple Dedekind Zeta Functions.*

In this talk we define multiple Dedekind zeta functions as a new type of higher dimensional iterated integrals, which are the key technical ingredient. Multiple Dedekind zeta functions can be written as infinite sums. They have integral representation and meromorphic continuation. We also prove that at the positive integers the multiple Dedekind zeta values are periods. In particular, the Dedekind zeta function can be written in terms of the new type of higher dimensional iterated integral and at the positive integers the corresponding iterated integrals give periods, where the geometric object is the Weil restriction of scalars of one 1-dimensional projective space without 0, 1 and infinity over a number field K. (Received February 02, 2011)

1070-11-109 **Wilfried Schmid*** (schmid@math.harvard.edu), Department of Mathematics, 1 Oxford Street, Cambridge, MA 02138. *On the rapid decay of cuspidal automorphic forms.*

Cuspidal automorphic forms decay rapidly on Siegel sets. This fact is frequently used to establish the analytic continuation and functional equations of L-functions. Certain arguments, in particular Rankin-Selberg type integrals that also involve unipotent integrations, depend on the rapid decay on sets larger than Siegel sets. In the case of the exterior square L-function for GL(n), Jacquet-Shalika carefully establish the decay on the required type of set. Several authors subsequently referred to the Jacquet-Shalika argument as justification for the convergence of integrals these authors were considering. In some of these cases, the Jacquet-Shalika argument does not apply, resulting in a significant gap in the literature on L-functions. I shall describe a general criterion covering all of these cases. In addition, our argument applies to all smooth cuspidal automorphic forms, not just those that are K-finite, as is commonly assumed. In addition, these arguments show that for smooth, not necessarily K-finite cuspidal automorphic forms, moderate growth implies uniformly moderate growth, and hence rapid decay. This is joint work with Steve Miller. (Received February 02, 2011)

1070-11-116 **Kathrin Bringmann** and **Amanda Folsom***, Yale University, Mathematics Department, P.O. Box 208283, New Haven, CT 06520-8283. *Kac-Wakimoto characters, asymptotics, and mock modular forms.*

Recently, Kac and Wakimoto established specialized character formulas for irreducible highest weight modules, and established a main exponential term in their asymptotic expansions. Later works of the author and Bringmann-Ono show that these characters may be realized as parts of certain non-holomorphic modular functions. By exploiting the "modularity" of these characters, we improve upon the Kac-Wakimoto asymptotics, obtaining an asymptotic expansion with an arbitrarily large number of terms beyond the main term. This is joint work with Kathrin Bringmann (University of Cologne). (Received February 03, 2011)

1070-11-131 **Reinier Broker*** (reinier@math.brown.edu). *Computing modular polynomials.*

The classical modular polynomial Φ_n parametrizes elliptic curves together with a cyclic isogeny of degree n. These polynomials are important in many algorithms using elliptic curves, but their incredibly large size makes it very hard to compute them. In the 1980's, computing Φ_{11} was considered a major computational effort, and at the end of the 1990's the world record was $n = 359$. In this talk, I will present a new algorithm to compute Φ_n that has an almost optimal running time. The algorithm is based on special properties of certain non-maximal orders in imaginary quadratic fields. The algorithm easily handles large values of n, and our new record is $n = 5003$. (Received February 06, 2011)

1070-11-137 **John Cullinan*** (cullinan@bard.edu), Department of Mathematics, Bard College, Annandale-On-Hudson, NY 12401, and **Allison Pacelli**, **Zev Chonoles**, **Fan Wei**, **Hannah Hausman** and **Sean Pegado**. *Arithmetic of generalized Riunka polynomials.*

For each integer $\ell \geq 3$ Rikuna defined a polynomial $r(\ell, x, t)$ over a function field $K(t)$ (with K satisfying some mild hypotheses) whose Galois group is isomorphic to $\mathbf{Z}/\ell$. Moreover, these polynomials are generic in the sense that every $\mathbf{Z}/\ell$-extension of K arises as a specialization of $r(\ell, x, t)$.

We generalize Rikuna's polynomials in the context iterated rational functions, show that they give rise to finitely-ramified iterated towers, and compute their Galois groups. (Received February 07, 2011)

1070-11-145 **Xander Faber*** (xander@math.uga.edu). *Uniform bounds for rational iterated pre-images.* Let k be a number field, E/k an elliptic curve, and p a rational prime. A result of Manin from the late 1960s asserts that one can uniformly bound the p-part of the group of k-rational points $E(k)$ in terms of p and k alone. I will discuss a dynamical analogue of this result for rational functions on the projective line and some related geometric questions. (Received February 07, 2011)

1070-11-173 **Jing Long Hoelscher*** (jlong@math.uic.edu), 851 S. Morgan Str, Department of Math (M/C 249), University of Illinois at Chicago, Chicago, IL 60607-7045. *Infinite class field towers.*

For a number field ramified only at one finite prime over $\mathbb{Q}$, Schmithals gave an example of $\mathbb{Q}(\sqrt{-3321607})$, where the only finite prime ramified is 3321607. It has an infinite 3-class field tower. Later Rene Schoof extended this result and showed that $K = \mathbb{Q}(\zeta_{877})$, $\mathbb{Q}(\sqrt{39345017})$ and $\mathbb{Q}(\sqrt{-222637549223})$ each have an infinite class field tower where the only finite primes ramified in $K/\mathbb{Q}$ are respectively 877, 39345017 and 222637549223. I will give examples of number fields ramified only at one small finite prime p, e.g. $p = 2, 3$ and 5, which have infinite class field towers. (Received February 09, 2011)

1070-11-175 **Kristin Lauter** and **Bianca Viray*** (bviray@math.brown.edu). *Bounding denominators of Igusa class polynomials using arithmetic intersection theory.* Preliminary report.

The roots of Igusa class polynomials parametrize genus 2 curves whose Jacobian have CM. Giving a sharp bound for the denominators of these Igusa class polynomials is useful for cryptography. We outline how arithmetic intersection theory can translate the problem of finding a sharp bound into a problem about counting embeddings of certain rings of integers into endomorphism rings of products of super-singular elliptic curves. We give an exact formula for the number of these embeddings and will give a high-level sketch of the proof. (Received February 09, 2011)

1070-11-177 **David E. Rohrlich*** (der@bu.edu), Department of Mathematics and Statistics, Boston University, Boston, MA 02215. *Counting Artin representations.*

Our motivating question is whether self-dual L-functions – those for which the functional equation relates the L-function to itself – have density zero among all L-functions. In the case of Artin L-functions, a theorem of R. Greenberg and of Anderson, Blasius, Coleman, and Zettler makes it possible to formulate the question precisely. Fix an integer $n \geqslant 1$ and let $\vartheta(x)$ be the number of isomorphism classes of n-dimensional complex representations of $\mathrm{Gal}(\overline{\mathbb{Q}}/\mathbb{Q})$ with conductor $\leqslant x$. Let $\vartheta^{\mathrm{sd}}(x)$ be the number of such classes that are self-dual. The problem is then to determine whether $\lim_{x\to\infty} \vartheta^{\mathrm{sd}}(x)/\vartheta(x) = 0$. If $n = 1$ then it is easy to see that $\vartheta(x) \sim (36/\pi^4)x^2$ and $\vartheta^{\mathrm{sd}}(x) \sim (6/\pi^2)x$, whence the answer is affirmative in this case. We shall focus on the case $n = 2$, where the work of Serre and of Duke bounding the dimension of spaces of modular forms of weight one gives a good idea of what to expect. (Received February 09, 2011)

1070-11-190 **Dmitry Kleinbock*** (kleinboc@brandeis.edu), Department of Mathematics, Brandeis University, Waltham, MA 02454, and **Gregory Margulis** and **Junbo Wang**. *Dirichlet's theorem, nonplanarity in the space of matrices, and homogeneous flows.* Preliminary report.

We present a condition on an analytic submanifold in the space of $m\times n$ matrices which guarantees that Dirichlet's theorem cannot be infinitely improved for almost all its points. The main tool is quantitative nondivergence in the space of lattices. The exposition will be given for the simplest interesting case, $m = n = 2$. (Received February 10, 2011)

1070-11-202 **Alvaro Lozano-Robledo*** (alvaro.lozano-robledo@uconn.edu), Department of Mathematics, 196 Auditorium Road, University of Connecticut, U-3009, Storrs, CT 06269. *On the field of definition of p-torsion points on elliptic curves over the rationals.*

Let $S_{\mathbb{Q}}(d)$ be the set of primes p for which there exists a number field K of degree $\leq d$ and an elliptic curve E/K, with $j(E) \in \mathbb{Q}$, such that the order of the torsion subgroup of $E(K)$ is divisible by p. In this talk, we give bounds for the primes in the set $S_{\mathbb{Q}}(d)$. Moreover, we determine $S_{\mathbb{Q}}(d)$ for all $d \leq 22$, and give a conjectural formula for all $d \geq 1$. If Serre's uniformity question is answered positively, then our conjectural formula is valid for all sufficiently large d. (Received February 11, 2011)

1070-11-214 **Francesco Cellarosi*** (fcellaro@math.princeton.edu), Department of Mathematics - Fine Hall, Princeton University, Washington Road, PRINCETON, NJ 08544-0001. *On the Möbius function and Statistical Mechanics.*

I will present a recent joint work with Ya.G. Sinai. We investigate the "randomness" of the classical Möbius function by means of a statistical mechanical model for square-free numbers and we prove some new results, including a non-standar limit theorem. This work is inspired by a conjecture by P. Sarnak, and by a number of recent results relating Number Theory and Ergodic Theory. (Received February 12, 2011)

1070-11-251 **Joshua Holden** (holden@rose-hulman.edu), Department of Mathematics, Rose-Hulman Insitute of Technology, Terre Haute, IN 47803, and **Margaret M Robinson*** (robinson@mtholyoke.edu), Department of Mathematics, 50 College Street, South Hadley, MA 01075. *Counting fixed points, two-cycles, and collisions of the discrete logarithm using p-adic methods.* Preliminary report.

Brizolis asked for which primes does there exist a pair (g, h) such that $g^h \equiv h \bmod p$. To rephrase, he asked if for $p > 3$ there is always a pair (g, h) such that h is a fixed point of the discrete logarithm $\log_g$. Zhang (1995) and Cobeli and Zaharescu (1999) answered with a "yes" for sufficiently large primes and gave estimates for the number of such pairs when g and h are primitive roots modulo p. In 2000, Campbell showed that the answer to Brizolis was "yes" for all primes. The first author has extended this question to questions about counting fixed points, two-cycles, and collisions (pairs (h, a) where $h^h \equiv a^a \bmod p$ where h and a are not necessarily primitive roots). In this paper, we use p-adic methods, primarily Hensel's lemma and p-adic interpolation, to count fixed points, two cycles, and collisions given certain conditions on g, h, and a modulo powers of a prime p. (Received February 14, 2011)

1070-11-269 **Cameron McLeman*** (mclemanc@umflint.edu) and **Kirti Joshi**. *Infinite Hilbert Class Field Towers from a Single Ramified Prime.*

Most constructions of fields with an infinite Hilbert class field tower stem from exhibiting a large number of ramified primes. These include, for example, the quadratic number fields studied by Golod and Shafarevich, and the cyclotomic fields studied by Furuta. Motivated by the investigation of fixed fields of Galois representations, we study Hilbert class field towers of number fields with a single ramified prime. In particular, we prove that under a conjecture of Hardy and Littlewood on primes in quadratic progressions, there exist infinitely many prime p such that the number field $\mathbb{Q}(\zeta_p)$ has an infinite Hilbert class field tower. (Received February 14, 2011)

1070-11-281 **Nigel Boston*** (boston@math.wisc.edu), Department of Mathematics, University of Wisconsin, Madison, WI 53706, and **Michael R. Bush** and **Farshid Hajir**. *Heuristics for p-Class Towers of Imaginary Quadratic Fields.* Preliminary report.

Let p be an odd prime and K an imaginary quadratic field. The Galois group of the maximal unramified p-extension of K is a Schur σ-group. We study how frequently a given Schur σ-group arises in this way, and propose possible heuristics similar to earlier ones of Cohen-Lenstra and Boston-Ellenberg. (Received February 14, 2011)

1070-11-313 **Andrew Knightly***, Department of Mathematics & Statistics, 5752 Neville Hall, Rm 333, University of Maine, Orono, ME 04469-5752, and **Charles Li**, Chinese University of Hong Kong, Hong Kong. *Newforms of cubic level.*

We produce a new vector in the simple supercuspidal representations of $\mathrm{GL}_n(\mathbf{Q}_p)$ constructed by Gross and Reeder, and compute the associated matrix coefficient when $n = 2$. This allows us to spectrally isolate newforms of level N^3, where N is square-free. Applications include a simple Kuznetsov formula and an exact expression for a weighted average of Maass newform L-values. (Received February 15, 2011)

1070-11-314 **Dragos Ghioca**, **Liang-Chung Hsia** and **Thomas J Tucker*** (tjtucker@gmail.com). *Towards a dynamical Pink-Zilber conjecture.*

Let f_λ be a family of polynomials over the complex numbers, with λ varying, subject to certain hypotheses. Let a_λ and b_λ be two families of points with λ varying. We show that if there are infinitely many choices of complex z such that a_z and b_z are both preperiodic for f_z, then a_λ and b_λ satisfy a very simple relation. This can be interpreted geometrically as a dynamical variant of the Pink-Zilber conjecture for families of semiabelian varieties. The techniques here follow work of Baker, DeMarco, Masser, and Zannier. (Received February 16, 2011)

1070-11-316 **Keith R Ouellette*** (kouellet@holycross.edu), Department of Mathematics and Comp. Sci., College of the Holy Cross, 1 College Street, Worcester, MA 01610. *On the Fourier inversion theorem for the full modular group.*

We offer a new proof of the Fourier inversion and Plancherel formulae for Maass-Eisenstein wave packets. The proof uses truncation, basic analysis, and classical Fourier theory. Brief sketches of the proofs due to Langlands, Lapid, and Casselman are then presented for comparison. (Received February 15, 2011)

1070-11-335 **Jeffrey Hoffstein***, jhoff@math.brown.edu. *Shifted Multiple Dirichlet Series and Applications.*

I'll explain what shifted convolutions are and show how they can interact with the theory of multiple Dirichlet series, with number theoretic applications. I will assume no previous knowledge of either subject. (Received February 15, 2011)

14 ► Algebraic geometry

1070-14-59 **Kenneth B Ascher*** (kennyascher@gmail.com), SUNY Stony Brook, Department of Mathematics, 100 Nicolls Road, Stony Brook, NY 11794. *Random Trinomials & Lower Binomials.*

There is no general formula, using rational functions and radicals, to determine real roots of polynomials of degree 5 or more. We show how to compute the number of real, non-zero roots of trinomials (of arbitrary degree) using a simple logarithmic inequality. Using the log-uniform distribution for the coefficients, we prove that the number of real roots is $\frac{3}{2}$ on average. We then present generalizations of this result to polynomials with an arbitrary number of terms (t-nomial). Finally, we show how an "Archimedian" Newton Polygon gives an algorithm to efficiently approximate the roots of f. This work was conducted under Profesor J. Maurice Rojas as part of the 2010 Math REU at Texas A&M University. (Received January 20, 2011)

1070-14-113 **Uli Walther*** (walther@math.purdue.edu), 150 N University Street, Dept of Math, Purdue University, West Lafayette, IN 47906, and **Manoj Kummini**. *Remarks on a conjecture of G. Lyubeznik.*

We discuss a new vanishing theorem for etale cohomology groups on open sets U in projective space P over a separably closed field. Ingredients are (as expected) basic topological data about the complement X of U, as well as (unexpectedly) a property of X that has arithmetic flavor.

We then present a conjecture of Lyubeznik, relating etale cohomlogical dimension to quasi-coherent cohomological dimension.

Finally we show that the minimial triangulation of the real projective plane gives rise to a subspace arrangement whose complement violates Lyubeznik's conjecture. (Received February 03, 2011)

1070-14-226 **Nero Budur*** (nbudur@nd.edu), University of Notre Dame, Department of Mathematics, 255 Hurley Hall, Notre Dame, IN 46556. *Complements and higher resonance varieties of hyperplane arrangements.* Preliminary report.

Using vector bundles techniques, we study higher resonance varieties of an indecomposable hyperplane arrangement. We prove inequalities on their codimension and on the Betti numbers of the complement. Equivalently these are inequalities on the coefficients of the chromatic, or characteristic, polynomials. (Received February 13, 2011)

1070-14-231 **Mehdi Garrousian*** (mgarrous@uwo.ca), **Graham Denham** and **Mathias Schulze**. *A Geometric Proof for the Solomon-Terao Formula.* Preliminary report.

The Solomon-Terao formula is an expression of the characteristic polynomial of an arrangement in terms of the Hilbert series of its logarithmic modules. This talk is a preliminary report on a geometric proof that follows from a recursive computation of the intersection cycle of a certain variety when a homological condition is satisfied. Some generalizations to multiarrangements will be discussed if time permits. (Received February 13, 2011)

1070-14-282 **Emma Previato** (ep@math.bu.edu), Boston University, Department of Mathematics, 111 Cummington Street, Boston, MA 02215, and **Michael Robertson*** (mrob@bu.edu). *Number of points on elliptic curves over families.*

Adapting, and experimenting with, Schoof's algorithm to count the number of points of an elliptic curve: $y^2 = x^3 + Ax + B$ over a finite field (characteristic $p \neq 2$) of p^k elements, the following observation was made: calling this number $\zeta(A, B)$ (for it is a zeta-function value), we noticed when $p \equiv 1 \pmod 4$, $\zeta(A, B) = \zeta(A, -B)$,

whereas when $p \equiv 3 \pmod 4$, $\zeta(A,B)+\zeta(A,-B) = 2(p^k+1)$, so that, in particular, if one curve has the maximum possible number of points among elliptic curves over that field, the other has the minimum. In this talk, our experiments will be illustrated with tables and a theoretical proof of the observation will be sketched. We are in the process of completing the analysis for $p = 2$, and intend to look for analogous properties in the case of hyperelliptic curves, $y^2 = x^{2g+1} + A_{2g-1}x^{2g-1} + ... + A_0$. This project was funded by UROP (Undergraduate Research Opportunities Program) of Boston University in the summer 2010, with the title "Elliptic Curve Cryptography," under the advisorship of Emma Previato. (Received February 14, 2011)

1070-14-297 **Lev Birbrair**, **Walter Neumann** and **Donal O'Shea*** (doshea@mtholyoke.edu), Dean of Faculty Office, Mount Holyoke College, South Hadley, MA 01075. *Exceptional Lines and Separating Sets at Singular Points of Complex Surfaces.* Preliminary report.

Let $(V,p) \subset (\mathbf{C}^n, 0)$ be a surface. The *Nash fiber* at 0 is defined as the limit of the tangent spaces to V, thought of as points in the appropriate Grassmanian, at smooth points $x \in V$ as x tends to 0. This analytic invariant does a much better job of capturing the geometry of the surface than either the Zariski tangent cone or the real cone over the link of the singularity. Its structure has been elucidated by Lê, Teissier and others, who show that the Nash fiber of V (at 0) consists of the Nash fiber of the Zariski tangent cone $(CV, 0)$ (that is, all limits of tangent spaces to the reduced tangent cone) together with finitely many, possibly zero, pencils of planes whose axes are lines, called *exceptional lines*, in CV through 0 (and which can be characterized complex-analytically in different ways). If $0 \in V$ is an isolated singularity and if $(V, 0)$ has a separating set (a three-dimensional semi-algebraic subset with real tangent cone at 0 of real dimension less than three), then we show that the tangent cone to the separating set lies in an exceptional line. (Received February 15, 2011)

1070-14-303 **Gregory Burnham**, **Zvi Rosen** and **Jessica Sidman*** (jsidman@mtholyoke.edu), Department of Mathematics and Statistics, Mount Holyoke College, South Hadley, MA 01075, and **Peter Vermeire**. *Line arrangements modeling curves: equations and syzygies.* Preliminary report.

In this talk we will discuss connections between the combinatorics of certain line arrangements that model high degree smooth curves embedded in projective space and the ideal of the arrangement. We will also discuss the higher dimensional subspace arrangements that arise as secant varieties of line arrangements. (Received February 15, 2011)

1070-14-324 **Alon Levy*** (levy@math.columbia.edu). *The Rationality of the Space of Morphisms on $\mathbb{P}^1$.*

We investigate families of rational maps, collected in the moduli spaces Rat_d of morphisms on $\mathbb{P}^1$. The space Rat_d has a quotient by the conjugation action of $PGL(2)$, which we denote M_d. We prove that this quotient has nice geometric properties, in the sense of geometric invariant theory, and that the space M_d is rational for each d. (Received February 15, 2011)

1070-14-329 **H Schenck***, Math Dept, UIUC, 1409 W. Green St., Urbana, IL 61801. *Resonance varieties via blowups of $\mathbb{P}^2$ and scrolls.*

Conjectures of Suciu relate the fundamental group of an arrangement complement $M = \mathbb{C}^n \setminus A$ to the first resonance variety of $H^*(M, \mathbb{Z})$. We describe a connection between the first resonance variety and the Orlik-Terao algebra $C(A)$ of the arrangement. In particular, we show that non-local components of $R^1(A)$ give rise to determinantal equations for $C(A)$. As a result, $Proj(C(A))$ lies on a scroll, placing geometric constraints on $R^1(A)$. The key observation is that $C(A)$ is the homogeneous coordinate ring associated to a nef but not ample divisor on blowup of $\mathbb{P}^2$ at the singular points of A. (Received February 15, 2011)

1070-14-336 **Ted Chinburg*** (ted@math.upenn.edu), Ted Chinburg, Department of Mathematics, University of Pennsylvania, Philadelphia, PA 19104, and **Matthew Stover**. *Generating arithmetic groups by small subgroups.* Preliminary report.

This talk will be about the generation of certain arithmetic groups by a small number of arithmetic Fuchsian subgroups. This has applications to a question of Langlands about the possible simple factors of the Albanese varieties of arithmetic Picard surfaces. (Received February 15, 2011)

15 ► Linear and multilinear algebra; matrix theory

1070-15-178 **Steven J Miller*** (sjm1@williams.edu), Bronfman Science Center, Williams College, Williamstown, MA 01267. *Painleve VI and Tracy-Widom Distributions in Random Graphs, Random Matrix Theory and Number Theory.*

We report on two occurances of Painleve VI and Tracy Widom distributions. The first is in number theory and random matrix theory, where the observed repulsion near the central point of low-lying zeros of elliptic curve L-functions can be explained by a discretized random matrix ensemble, where the first eigenangle above 1 is given by a Painleve VI equation. The second involves the distribution of the second largest eigenvalue of d-regular graphs, which we show numerically is well-modeled by the beta = 1 Tracy-Widom distribution. If the observed growth rates of the mean and standard deviation as a function of the number of vertices holds in the limit, then in the limit approximately 52% (resp. 26%) of bipartite (resp. non-bipartite) d-regular graphs should be Ramanujan. (Received February 10, 2011)

16 ► Associative rings and algebras

1070-16-19 **Atabong T Agendia*** (tagendia@yahoo.com), **M O Oyesanya** (mose.oyesanya@unn.ng) and **G A Ngwa**. *A fractional reaction diffusion model for tumor development as a result of deformation (destruction) of biological protein materials (BPM) in the body.*

A fractional reaction diffusion model for tumor to capture the fractal nature of tumor and the random but continuous deformation and destruction of biological protein materials in a human system is proposed. We carried out an indebt fractional analysis of this model before simulating the resulting non-linear system numerically. In the fractional diffusion model, the second order integer derivative with respect to space is replaced with a non integer value. Such anomalous diffusive models have proven very useful in fluid flow in porous media and Brownian motion. A set of five equations representing, the stress mechanics (P), the glycolitic release of H+ in the tissues (H), the reserved temperature of the tissue (T), the normal tissue mechanics (N) and the tumor tissue mechanics (M) forms the clone of the model. Our analysis shows that there exists at least one non-trivial equilibrium state under which if the bond breaking speed is kept within a certain magnitude, the tumor will metastasized into full grown cancer. As a result, we equally show that increasing the amount of water in the body system can remedy the metastasis of tumor into cancer. (Received December 04, 2010)

1070-16-24 **Sorin Dascalescu**, Str Academiei 14, Sect 1, 010014 Bucharest, Romania, **Miodrag C Iovanov*** (yovanov@gmail.com), Str. Academiei 14, Sect 1, 010014 Bucharest, Romania, and **Constantin Nastasescu**, Str. Academiei 14, Sect 1, 010014 Bucharest, Romania. *Infinite path and incidence (co)algebras: Frobenius and finiteness properties and new classes of quantum groups.*

An object of central interest in representation theory is that of representation of a quiver. More generally, interesting algebras arise in various fields as quotients of quiver algebras by relations generated by paths. The quiver coalgebra is tightly connected to the quiver algebra, and sometimes they be recovered from each other. We look at two combinatorial objects: quivers and locally finite PO-sets. A question of general interest is when such (co)algebras can be endowed with a Hopf algebra structure, i.e. when their category of (co)representations has the extra structure of a tensor category. We look at a very important class of Hopf algebras, namely those with non-zero integral, which generalize algebras of functions on a compact group. They have a special representation theoretic property: their category of (co)representations is Frobenius. We analyze this property for path (co)algebras and more general for subcoalgebras of quiver coalgebras which have a basis of paths, and for incidence coalgebras of PO sets. We give a unitary approach for these two types of combinatorial objects, and give combinatorial characterizations for this condition. We classify these structures, as well as the Hopf algebras arising this way; this defines an interesting and wide class of algebras. (Received December 13, 2010)

1070-16-265 **Zajj B Daugherty*** (daugherz@stolaf.edu), **Arun Ram** and **Rahbar Virk**. *The degenerate affine BMW algebra and its center.* Preliminary report.

The *degenerate affine BMW algebra* W_k was introduced by Nazarov (there called the *affine Wenzl algebra*) in his study of the Brauer algebras via Jucys-Murphy elements. It arises in Schur-Weyl duality with the orthogonal and symplectic Lie algebras in the same way that the graded Hecke algebra of type A is in Schur-Weyl duality with the Lie algebras $\mathfrak{gl}_n$ and $\mathfrak{sl}_n$, and therefore exhibits many similarities in structure. We will explore how results arise for W_k which parallel those for the graded Hecke algebra, describing, for example, its center as a ring of symmetric functions. (Received February 14, 2011)

17 ► Nonassociative rings and algebras

1070-17-222 **Michael R Penkava*** (penkavmr@uwec.edu), Department of Mathematics, University of Wisconsin-Eau Claire, 105 Garfield Avenue, Eau Claire, WI 54702-4004, **Alice Fialowski** (fialowsk@cs.elte.hu), Eotvos Lorand University, Budapest, Hungary, **Joshua Frinak** (frinakjj@uwec.edu), University of Wisconsin-Eau Claire, and **Austen Ott** (ottai@uwec.edu), University of Wisconsin-Eau Claire. *Modules and Extensions of Infinity Algebras.*

The notion of an extension of an infinity algebra by another infinity algebra has parallels to the classic extension picture for associative or Lie algebras. In this talk, we give a definition of module which is more general than has appeared in the literature, appropriate for the notion of extensions by a module. We give a more restricted version of a morphism of infinity algebras, which is well behaved under kernel and cokernel operations. The leading term of an infinity algebra is an infinity algebra of fixed degree, which means that reducing to extensions of an algebra of fixed degree by a similar one is the most important step in constructing general extensions. We introduce a descending set of coboundary operators, each defined on the previous cohomology, which is related to the construction of extensions. Finally, we have constructed all infinity algebras of some low degrees for some low dimensional A-infinity algebras, and find that some simple algebras have nontrivial deformations. (Received February 12, 2011)

18 ► Category theory; homological algebra

1070-18-34 **Vasily A. Dolgushev*** (vald@temple.edu). *Formality theorem for Hochschild cochains via transfer.*

I will talk about a 2-colored operad G^+ which, on the one hand, extends the operad G of homotopy Gerstenhaber algebras and, on the other hand, extends the 2-colored operad of open-closed homotopy algebras (OCHA). I will show that Tamarkin's G-structure on the Hochschild cochain complex $C^*(A)$ of an A_∞ algebra A extends naturally to a G^+ structure on the pair $(C^*(A), A)$. I will show that a formality quasi-isomorphism for the Hochschild cochains of the polynomial algebra can be obtained via transfer of this G^+ structure to the cohomology of the pair $(C^*(A), A)$. Finally, I will discuss a link between the operad G^+ and Voronov's Swiss Cheese operad. (Received December 20, 2010)

1070-18-39 **John Terilla**, Math Department, CUNY Queens College, 65-30 Kissena Blvd, Flushin, NY 11367, **Thomas Tradler**, New York City College of Technology, City University of New York, 300 Jay Street, Brooklyn, NY 11201, and **Scott O Wilson***, Math Department, CUNY Queens College, 65-30 Kissena Blvd, Flushing, NY 11367. *Homotopy associative algebras induce homotopy Batalin-Vilkovisky algebras.*

Let TA denote the space underlying the tensor algebra of a vector space A. If A is a differential graded algebra, then TA is a differential Batalin-Vilkovisky algebra. Moreover, if A is an A_∞ algebra, then TA is a commutative BV_∞ algebra. (Received December 20, 2010)

1070-18-171 **Mindy Capaldi** and **Thomas Lada*** (lada@math.ncsu.edu). *L_∞-algebras and Symmetric Brace Algebras.* Preliminary report.

Symmetric brace algebras can be used to describe L_∞ - algebras. In this talk we will describe L_∞-algebra morphisms using symmetric braces. We will also show how one may deform a given L_∞- algebra on a vector space to a new algebra structure on the same underlying space. (Received February 09, 2011)

1070-18-307 **John Huerta*** (huerta@math.ucr.edu). *Higher supergroups for string and M-theory.*

In their theory of generalized connections, Sati, Schreiber, and Stasheff propose that supergravity is governed by an L-infinity algebra extending the Poincaré algebra in 11-dimensional spacetime. I will describe how this is part of a sequence of L-infinity algebras which extend the Poincaré algebra: there are similar extensions in dimensions 4, 5, 7 and 11, where classical supersymmetric 2-branes can be defined, and in dimensions 3, 4, 6 and 10, where classical superstrings can be defined. I will show how these can all be integrated to "categorified supergroups" which extend the Poincaré supergroups in the same dimensions, suggesting that the generalized connections for these L-infinity algebras can be understood as connections on categorified bundles. (Received February 15, 2011)

20 ► Group theory and generalizations

1070-20-36 **Oliver Ruff*** (oruff@kent.edu). *Centers of cyclotomic Hecke algebras.*

The algebras collectively referred to here as *cyclotomic* arise in a variety of contexts as families of finite-dimensional quotients of a larger affine algebra. These families of quotients can often be interpreted as being indexed by weights in a way that exhibits deep connections with Lie theory. The most classical example is the degenerate affine Hecke algebra of type A, where the group algebra of the symmetric group appears as the cyclotomic quotient associated with the highest weight of the natural representation of $\mathfrak{sl}_n$.

In this talk we will discuss a combinatorial description of the centers of certain cyclotomic algebras, focusing on the degenerate and quantum cyclotomic Hecke algebras of type A and the cyclotomic Sergeev superalgebras: these are relevant to the representation theory of - respectively - the symmetric group and its double cover. As time permits we will also discuss the analogous case of the degenerate cyclotomic Birman-Murakami-Wenzl algebra, which includes as a special case the classical Brauer algebra. (Received December 20, 2010)

1070-20-99 **Alireza Salehi Golsefidy*** (asalehi@math.princeton.edu), Mathematics Dept. (Fine Hall), Washington road, Princeton, NJ 08544-1000, and **Peter Sarnak** and **Peter Varju**. *Affine sieve and expanders.*

I will talk about the fundamental theorem of affine sieve (joint with Sarnak). The main black box in the proof of this result will be also explained. It is a theorem on a necessary and sufficient condition for a finitely generated subgroup of SL(n,Q) under which the Cayley graphs of such a group modulo square free integers form a family of expanders (joint with Varju). (Received February 01, 2011)

1070-20-102 **Steven V Sam*** (ssam@math.mit.edu) and **Jerzy Weyman**. *Geometric approach to Littlewood inversion formulas.* Preliminary report.

Littlewood gave branching rules for restricting representations of the general linear groups to orthogonal and symplectic groups as well as inversion formulas for how to write an irreducible character for an orthogonal/symplectic group as an alternating sum of Schur functions. These inversion formulas are encoded in the minimal free resolutions of certain concretely defined algebraic varieties associated to these groups. I will explain this connection and say something about what happens in the case of exceptional groups and symmetric groups. The motivation for these varieties comes from previous investigations into the tensor product saturation problem, and time permitting, I will say something about the connection. (Received February 02, 2011)

1070-20-133 **Richard M Green*** (rmg@euclid.colorado.edu), Department of Mathematics, University of Colorado at Boulder, Campus Box 395, Boulder, CO 80309-0395. *Polytopal subcomplexes and homology representations of Coxeter groups.*

Let v be a nonzero point in Euclidean space on which a finite Coxeter group W acts by reflections. The convex hull of the points $W.v$ is a geometrically and combinatorially interesting polytope on which W acts as automorphisms. Discrete Morse theory is a purely combinatorial theory that is useful for computing homology groups arising in combinatorial topology. I will discuss the problem of finding a complete acyclic Morse matching on the face lattices of these polytopes. Discrete Morse theory then tells us that the polytope has the homotopy type of a point, which we knew anyway because polytopes are contractible. The talk will explain how this seemingly useless construction can be used to understand certain homology representations of Coxeter groups. (Received February 06, 2011)

1070-20-141 **Daniel C Cohen*** (cohen@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Pure braid groups are not residually free.*

We show that the Artin pure braid group on at least four strands is not residually free. (Received February 07, 2011)

1070-20-163 **Matthew J. Dyer*** (dyer.1@nd.edu), Department of Mathematics, 255 Hurley Building, University of Notre Dame, South Bend, IN 46614. *Groupoids with root systems.* Preliminary report.

Properties of a class of groupoids with (abstract) root systems will be discussed. Examples arise naturally from Coxeter groups, Coxeter groupoids and real simplicial hyperplane arrangements, for example. Their properties include notably that they form a closed class under a basic construction not previously known in general in the examples. (Received February 08, 2011)

1070-20-211 **Dana C. Ernst**, **Richard M. Green** and **Matthew Macauley***, macaule@clemson.edu.
Towards a cyclic version of Matsumoto's theorem. Preliminary report.

A classic result in Coxeter groups, often known as Matsumoto's theorem, states that any two reduced expressions of the same word differ by a sequence of braid relations. Cyclically shifting a reduced expression is a conjugation by the initial letter, so we ask the following question: "Do two cyclically reduced expressions of conjugate elements differ by a sequence of braid relations and cyclic shifts?" An affirmative answer would be a "cyclic version" of Matsumoto's theorem, and would be to the conjugacy problem what Matsumoto's theorem is to the word problem. Though it fails in general, it seems to "usually be true". In this talk, I will discuss our efforts to attack this problem and show some interesting algebraic combinatorics that has resulted. (Received February 12, 2011)

1070-20-227 **Alireza Salehi Golsefidy** and **Peter P. Varju*** (pvarju@princeton.edu).
Property (τ) *for thin groups.*

Let $\Gamma < SL_d(\mathbf{Z})$ be a finitely generated subgroup. We show that it has property (τ) with respect to the congruence subgroups $\Gamma_q = \{g \in \Gamma : g \equiv 1 \bmod q\})$ for q square-free, if and only if the connected component of the Zariski closure of Γ is perfect. The result has applications to sieving in orbits in number theory. (Received February 13, 2011)

1070-20-254 **Vivien Ripoll*** (vivien.ripoll@lacim.ca), Universite du Quebec a Montreal, CP 8888, Succ. Centre-ville, Montreal, QC H3C 3P8, Canada.
Geometrical enumeration of certain factorisations of a Coxeter element in finite reflection groups.

When W is a finite reflection group, the noncrossing partition lattice NCP_W of type W is a very rich combinatorial object, extending the notion of noncrossing partitions of an n-gon. A nice formula (but for which the only known proofs are case-by-case) expresses the number of multichains of a given length in NCP_W as a generalized Fuss-Catalan number, depending on the invariant degrees of W. We describe, from a geometrical point of view, some new refinements of a specification of this formula, in terms of "submaximal block factorizations" of a Coxeter element of W. The enumeration of these factorizations involves specific properties of the discriminant hypersurface of W. The (case-free) proof uses an interpretation of the block factorizations as fibers of the "Lyashko-Looijenga covering" of type W. (Received February 14, 2011)

22 ► Topological groups, Lie groups

1070-22-246 **Nimish A Shah*** (shah@math.osu.edu), The Ohio State University, Dept of Mathematics, 100 Math Tower, 231 W 18th Ave, Columbus, OH 43210-1174, and **Hee Oh**.
Geodesic evolution of certain measures on unit normal bundles of closed totally geodesic submanifolds in geometrically finite hyperbolic spaces.

On the unit normal bundle of a closed totally geodesic immersions in a geometrically finite hyperbolic space, we describe certain measures associated to the Patterson-Sullivan measures on the boundary. We obtain geometric interpretations of finiteness of these measures. We also description of the limiting distributions of the evolution of these measures under the geodesic flow. The results have applications to orbital counting for actions of geometrically finite hyperbolic groups. (Received February 13, 2011)

26 ► Real functions

1070-26-20 **Pan Liu*** (liupan@wpi.edu), WPI 100 Institute RD, Mailbox 3608, Worcester, MA 01609.
A Two-Dimensional Polya-Type Map Filling a Pyramid.

We construct a family of Pólya-type volume-filling continuous maps from a rectangle onto a solid pyramid. The family is indexed by a parameter p between 1 and $+\infty$ which gives the equation of the base of the pyramid as $||x||^p + ||y||^p \leq 1$. We extend to these maps the differentiability results obtained by Peter Lax for the Pólya map and we study the limits as $p \to 1$ and $p \to \infty$. (Received January 28, 2011)

28 ► Measure and integration

1070-28-212 **Stanley Eigen*** (s.eigen@neu.edu) and **Arshag Hajian**. *Recurrent Sequences in Infinite Measure Spaces.*

Recurrent sequences for infinite measure preserving transformations were introduced in in the 1967. In 1970, Hajian and Kakutani gave a a complete description of all the recurrent sequences is given for the Hajian-Kakutani transformation. Since then, nothing has been done with recurrent sequences. The purpose of this note is to reintroduce recurrent sequences and illustrate their use as an isomorphism invariant. To this end, we construct an uncountable family of ergodic measure preserving transformations with different recurrent sequences. These transformations are variations of the Hajian-Kakutani transformation. They will all have the same alpha-type, so that cannot be used to distinguish them. They will all have a common exhaustive weakly wandering sequence, and the induced transformations on the associated exhaustive weakly wandering set will all be isomorphic. (Received February 12, 2011)

1070-28-230 **Randall McCutcheon*** (rmcctchn@memphis.edu), Department of Mathematical Sciences, 373 Dunn Hall, University of Memphis, Memphis, TN 38152. *On the size of the wildcard set in the IP Szemeredi and density Hales-Jewett theorems.* Preliminary report.

Furstenberg and Katznelson proved that the common difference of the arithmetic guaranteed to exist in any set of positive upper density by Szemeredi's theorem may be chosen from any IP set, namely from the set of finite sums of an arbitrary sequence. Our main theorem is a polynomial version of this fact. One may for example require the common difference of the progression to be a sum obtained by summing a square number of elements from the given arbitrary sequence. A similar conjecture, on which some progress has been made, may be formulated for the density Hales-Jewett theorem. (Received February 13, 2011)

30 ► Functions of a complex variable

1070-30-17 **Joseph A. Cima*** (cima@email.unc.edu), Dept. of Mathemtics, CB #3250, University of North Carolina, Chapel Hill, NC 27599. *Univalent functions related to Cauchy transforms.* Preliminary report.

Let $f(z)$ be an analytic function on the unit disc $\mathbb{D}$ which is the Cauchy transform of a finite Borel measure on the unit circle. By results of C. Pommerenke it can be shown that there is a normalized univalent function h on $\mathbb{D}$ and a positive number α so that f satisfies

$$h'(z) = e^{\alpha \int_0^z f(w)dw}$$

for z in the disc. We shall discuss some properties of the univalent function h in this setting. (Received December 03, 2010)

1070-30-85 **Peter Ebenfelt** (pebenfel@math.ucsd.edu), Department of Mathematics, University of California at San Diego, La Jolla, CA 92093, **Dmitry Khavinson*** (dkhavins@usf.edu), Department of Mathematics and Statistics, University of South Florida, Tampa, FL 33620, and **Harold S. Shapiro** (shapiro@telia.com), Department of Mathematics, Royal Institute of Technology, S-10044 Stockholm, Sweden. *"Fingerprints" of the Two Dimensional Shapes and Lemniscates.*

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 January 30, 2011)

1070-30-101 **John Wermer*** (wermer@math.brown.edu), 128 Irving Ave, Providence, RI 02906.
Function Algebras on Levi flat Sets. Preliminary report.

Let X be a compact 3-manifold with boundary, contained in C^2, such that X is exhausted by a family of finite Riemann surfaces S(t)where for each t bd(S(t)lies in bdX. A denotes the algebra of all functions f in C(X)such that for each t the restriction of f to S(t) is holomorphic on S(t). Let M be the maximal ideal space of A. Each point of X gives a point in M. Are there any other points in M? In "Function Theory on Certain 3-manifolds" (to appear) we showed that the answer is Yes when X has the equation: —w— = —G(z)—, (z,w)in the unit bidisk, with G holomorphic on the unit disk. John Anderson suggested that this result could be generalized.

Let H,K be holomorphic functions on the bidisk D(2). Put X = (z,W)— —H(z,w) = —K(z,w) on D(2). X is foliated by the Riemann surfaces:H(z,w)= K(z,w)exp(it) and A is defined as above. Conjecture: Let M be the maximal ideal space of A. Then M coincides with X. In this talk, we shall discuss partial results towards the conjecture. (Received February 02, 2011)

1070-30-124 **Paul M Gauthier*** (gauthier@dms.umontreal.ca). *Zero-free approximation.*

Suppose K is a compact subset of the complex plane and suppose that every continuous function on K, which is holomorphic on the interior of K^o, is the uniform limit of polynomials. Johan Andersson has conjectured that, then, every continuous function on K, which is holomorphic and {zero-free} on K^o, is the uniform limit of polynomials which are zero-free on K^o. Andersson also formulated a conjecture regarding the Riemann zeta-function and proved the remarkable fact that these two conjectures are equivalent. We present some new insights on these matters. (Received February 05, 2011)

1070-30-157 **R. A. Hibschweiler*** (rah2@unh.edu). *Composition Operators on Spaces of Fractional Cauchy Transforms.*

For $\alpha > 0$, the Banach space $\mathcal{F}_\alpha$ is the collection of analytic functions f which can be represented as integral transforms of an appropriate kernel defined on the unit circle. Let Φ be an analytic self-map of the disc and let C_Φ denote the operator defined by $C_\Phi(f) = f \circ \Phi$. Conditions on an analytic self-map Φ will be shown to imply that the operator C_Φ is bounded on $\mathcal{F}_\alpha$ in the case $0 < \alpha < 1$. (Received February 08, 2011)

1070-30-256 **André Boivin*** (boivin@uwo.ca) and **Changzhong Zhu** (czhu28@uwo.ca), Department of Mathematics, University of Western Ontario, Canada. *A Bi-orthogonal Expansion in the Space $L^2(0,\infty)$.* Preliminary report.

Assume that a sequence of complex numbers $\{\lambda_k\}$ $(k = 1, 2, \ldots)$ satisfies the conditions: $\Re(\lambda_k) > 0$, $\lambda_k \neq \lambda_j$ for $k \neq j$ and $\sum_{k=1}^{\infty} \frac{\Re(\lambda_k)}{1+|\lambda_k|^2} < +\infty$. It is known that under the above conditions, the Blaschke product $W(\xi) = \prod_{k=1}^{\infty} \left[\frac{\xi-\lambda_k}{\xi+\overline{\lambda}_k} \cdot \frac{|1-\lambda_k^2|}{1-\lambda_k^2} \right]$ converges to an analytic function $W(\xi)$ in the right half-plane $\Re(\xi) > 0$, and that the exponential system

$$\{e^{-\lambda_k x}\} \quad (k = 1, 2, \ldots) \tag{1}$$

is incomplete in $L^2(0,\infty)$. V. Kh. Musoyan (1986) also showed that if

$$\psi_k(x) = -\frac{1}{\overline{W'(\lambda_k)}} \cdot \frac{1}{2\pi} \int_{-\infty}^{+\infty} \frac{e^{-i\tau x}}{W(i\tau)(i\tau + \overline{\lambda}_k)} d\tau \quad (k = 1, 2, \ldots), \tag{2}$$

then the systems (1) and (2) are bi-orthogonal in $L^2(0,+\infty)$. Using the Fourier transform and corresponding results in the Hardy space H_+^2 for the upper half-plane, the bi-orthogonal expansions with respect to the systems (1) and (2) will be obtained. (Received February 14, 2011)

1070-30-259 **Mark David Comerford*** (mcomerford@math.uri.edu), 5 Lippitt Road, Room 200, Kingston, RI 02881. *Meridians and the Carathéodory Topology.*

We examine the following problem: given a hyperbolic domain $U \subset \overline{\mathbb{C}}$ and two disjoint closed sets E, F each containing at least two points such that $\overline{\mathbb{C}} \setminus U = E \cup F$, is there a shortest simple closed hyperbolic geodesic in U which separates these two sets? The answer to this question is yes, and such geodesics are known as meridians of the domain U. These curves are important for understanding the convergence of sequences of pointed domains with respect to the Carathéodory topology. We present some continuity results concerning convergence of meridians for convergent sequences of pointed domains. Using this we can give a boundedness criterion for a family of pointed domains of the same connectivity and none of whose complementary components is a point, such that any limit of a convergent sequence in such a family is another domain of the same type. (Received February 14, 2011)

1070-30-311 **Brian J. Cole** (Brian_Cole@brown.edu), Department of Mathematics, Brown University, Providence, Rhode Island 02912, U.S.A.. *A non-semialgebraic interpolation body.* Preliminary report.

Let A be a uniform algebra on a set X, and fix distinct points $\zeta_1, \ldots, \zeta_n$ in X. The associated *interpolation body* is the set

$$\mathcal{E} = \{\, (z_1, \ldots, z_n) \in \mathbf{C}^n \,\big|\, \forall \epsilon > 0 \ \exists f \in A,\ \|f\| < 1 + \epsilon,\ f(\zeta_i) = z_i,\ i = 1, \ldots, n \,\}.$$

Note that $\mathcal{E}$ is a compact, convex subset of $\mathbf{C}^n$. As a special case, consider $X = \Omega$, a complex manifold, and $A = H^\infty(\Omega)$. Pick's theorem describes $\mathcal{E}$ in terms of algebraic inequalities when Ω is the unit disk in $\mathbf{C}$, and hence $\mathcal{E}$ is a semialgebraic set in this case. More generally, it is known that $\mathcal{E}$ is semialgebraic when Ω is the unit bi-disk in $\mathbf{C}^2$ or a finite Riemann surface. In the negative direction, we prove the following

Theorem. *There exists an interpolation body $\mathcal{E}$ for a uniform algebra so that $\mathcal{E}$ is not semialgebraic.* (Received February 15, 2011)

32 ► Several complex variables and analytic spaces

1070-32-31 **John P. D'Angelo***, Dept. of Mathematics, Univ. of Illinois, 1409 W. Green St., Urbana, IL 61801. *Hermitian analogues of Hilbert's 17th problem.*

Let X be a subset of $\mathbf{C}^n$, and suppose that the function f takes positive values on X. We discuss the following general question: under what conditions on X and f is there a Hilbert space valued holomorphic function h such that $f = ||h||^2$ on X. In this talk we emphasize the case when X is real-algebraic and f is a (Hermitian) polynomial. (Received December 16, 2010)

1070-32-88 **Takuro Abe*** (abe.takuro.4c@kyoto-u.ac.jp), Department of Mechanical Engineering and, Science, Kyoto University, Yoshida Honmachi, Sakyo-ku, Kyoto, Kyoto 6068501, Japan. *Chambers and freeness of line arrangements.*

Connected components of the complement of a real line arrangement are called chambers. We give a lower bound of the number of chambers under certain conditions in terms of free (multi)arrangements and its exponents. This result is obtained from an interesting relation between the geometry and combinatorics of affine line arrangements and the algebra of central line multiarrangements. As an application we give a sufficient condition for a central plane arrangement to be free in terms of characteristic polynomials over any fields. (Received February 01, 2011)

1070-32-98 **David B. Massey*** (d.massey@neu.edu), Dept. of Mathematics, Northeastern University, Boston, MA 02115. *What do perverse sheaves tell you about the topology of analytic spaces?*

There are two canonical perverse sheaves associated with the rational constant sheaf on a complex analytic space X: the intersection cohomology complex and perverse cohomology. The (shifted) constant sheaf is isomorphic to its perverse cohomology if and only if the constant sheaf is perverse; in this case, one has all of the cohomological Milnor fiber theory for functions on X. The constant sheaf is isomorphic to intersection cohomology, which is a simple perverse sheaf, if and and only if X is a rational homology manifold; in this case, categorical techniques yield methods for producing new rational homology manifolds which may be very singular. Finally, we look at what it says about the topology of an analytic space when intersection cohomology and perverse cohomology of the constant sheaf coincide. (Received February 01, 2011)

1070-32-140 **Imre Patyi*** (ipatyi@gsu.edu), Department of Mathematics and Statistics, Georgia State University, 30 Pryor St, Atlanta, GA 30303-3083. *On complex Banach manifolds similar to Stein manifolds.*

We give an abstract definition, similar to the axioms of a Stein manifold, of a class of complex Banach manifolds in such a way that a manifold belongs to the class if and only if it is biholomorphic to a closed split complex Banach submanifold of a separable Banach space. (Received February 07, 2011)

1070-32-142 **Mehmet Çelik**, Mathematics, The University of North Texas at Dallas, 7300 University Hills Blvd., Dallas, TX TX 75241, and **Emil J. Straube***, Department of Mathematics, Texas A&M University, College Station, TX TX 77843. *On the ideal of compactness multipliers.*

Let Ω be a bounded pseudoconvex domain in $\mathbb{C}^n$. The compactness multipliers for the $\overline{\partial}$-Neumann problem form an ideal in $C(\overline{\Omega})$ whose zero set may be viewed as the obstruction to compactness: the $\overline{\partial}$-Neumann operator is compact if and only if this zero set is empty. We determine this set for convex domains in $\mathbb{C}^n$ and for complete Hartogs domains in $\mathbb{C}^2$. (Received February 07, 2011)

1070-32-224 **Anne Pichon*** (pichon@iml.univ-mrs.fr), Luminy, Case 907, Marseille, 13288. *On the topology of non isolated singularities of complex surfaces.*

To an analytic germ $f : (\mathbf{C}^3, 0) \longrightarrow (\mathbf{C}, 0)$, one can associate three classical underlying geometrical objects :

1) the link L_0 of the germ of complex surface $(X, 0)$ with equation $f = 0$,

2) the link $\tilde{L}_0$ of the normalization space of X, and

3) the boundary L_t of the Milnor fibre of $f^{-1}(0), t \neq 0$.

When f has an isolated singularity at 0, then it is well known that L_0, L_t and $\tilde{L}_0$ are diffeomorphic real 3-dimensional manifolds which are graphed in the sense of Waldhausen.

We study the case when the singular locus of f is a complex curve. In this case, these three spaces are in general not homeomorphic. A natural question is to describe them, and to compare them. I will present some results in this direction.

Our main result is that the boundary of the Milnor fibre L_t is a graphed manifold. I will sketch a proof of this this fact. I will also show through examples that L_t provides new 3-manifolds in complex geometry.

This is a joint work with Françoise Michel (University of Toulouse, France) (Received February 12, 2011)

1070-32-249 **Enrique Artal**, **Jose Cogolludo** and **Daniel Matei***, Institute of Mathematics "Simion Stoilow", Romanian Academy, P.O. Box 1-764, 014700 Bucharest, Romania. *Characteristic varieties of quasi-projective manifolds and orbifolds.*

We discuss characteristic varieties of quasi-projective manifolds improving on a theorem of Arapura. We show that the irreducible components of such characteristic varieties are either pull-backs of irreducible components of characteristic varieties for orbifold curves, or torsion points. This gives an interpretation for the translated components of the characteristic varieties, and shows that the zero-dimensional components are indeed torsion. The main result is applied to derive obstructions for a group to be the fundamental group of a quasi-projective manifold. (Received February 14, 2011)

1070-32-252 **Sushil Gorai*** (sushil@math.iisc.ernet.in), Department of Mathematics, Indian Institute of Science, Bangalore, Karnataka 560012, India. *Polynomial convexity of the union of more than two totally-real planes in* $\mathbb{C}^2$. Preliminary report.

In this talk, we shall discuss local polynomial convexity at the origin of the union of finitely many totally-real planes through $0 \in \mathbb{C}^2$. The planes, say $P_0, \ldots, P_N$, satisfy a mild transversality condition that enables us to present them in a normal form introduced by Weinstock. In this form, we have $P_0 = \mathbb{R}^2$ and $P_j = M(A_j) := (A + iI)\mathbb{R}^2,\ j = 1, \ldots, N$, where each A_j is a 2×2 matrix with real entries. Weinstock characterized polynomial convexity for $N = 1$. We shall demonstrate, using a characterization of simultaneous triangularizability of 2×2 matrices over the reals given by Florentino, a sufficient condition for local polynomial convexity at $0 \in \mathbb{C}^2$ of the union of the above planes. A lot more can be said when $N = 2$, even when the condition inspired by Florentino, which is a *closed* condition, does not hold. For three planes, we can study any generic (in an appropriate sense) triple, and we provide an *open* condition for local polynomial convexity. (Received February 14, 2011)

1070-32-257 **Al Boggess*** (boggess@math.tamu.edu), Mathematics Department, Texas A&M University, College Station, TX 77843, and **Andy Raich**, Mathematics Department, University of Arkansas, Fayettville, AR. *New Formulas for the Fundamental Solution to* $\Box_b$ *on Certain Quadrics.* Preliminary report.

In 2003, M. Peloso and F. Ricci gave necessary and sufficient conditions for the solvability of $\Box_b$ on (0,q) forms for quadric surfaces in C^n of any codimension. Where solvability is possible, they also gave a formula for the group transform of the fundamental solution in terms of a Hermite expansion. In joint work with Andy Raich, we can evaluate a closed form expression for the fundamental solution to $\Box_b$ for certain types of quadrics. In particular, for hypersurface quadrics, these formulas exhibit the dependence of the fundamental solution on the relative sizes of the absolute values of the eigenvalues of the Levi form. (Received February 14, 2011)

1070-32-261 **John T. Anderson*** (anderson@mathcs.holycross.edu), Dept. of Mathematics and Computer Science, College of the Holy Cross, Worcester, MA 01610-2395. *Uniform Approximation by* $\Box_b$ *–harmonic functions.*

The Mergelyan and Ahlfors-Beurling estimates for the Cauchy transform give quantitative information on uniform approximation on a compact plane set K by rational functions with poles off K. We will present an analogous result for an integral transform on the unit sphere in $\mathbb{C}^2$ introduced by Henkin, and show how it can be used to study approximation by functions that are locally harmonic with respect to the Kohn Laplacian $\Box_b$. (Received February 14, 2011)

1070-32-289 **David E Barrett*** (barrett@umich.edu), Math Department, 530 Church St, Ann Arbor, MI 48109-1043. *Isoperimetric problems and Sobolev inequalities in several complex variables.* Preliminary report.

The talk will examine relations between the following three topics:

- isoperimetric problems connected with Fefferman's surface measure for strongly pseudoconvex boundaries;
- sub-Riemannian Sobolev inequalities and related extensions of a Hardy-Littlewood inequality;
- the CR Yamabe problem studied by Jerison and Lee.

(Received February 14, 2011)

1070-32-293 **Siqi Fu*** (sfu@camden.rutgers.edu), Department of Mathematical Sciences, Rutgers University, Camden, NJ 08102. *Problems in spectral theory of the $\bar{\partial}$-Neumann Laplacian.* Preliminary report.

In this talk, I will discuss several results and problems in spectral theory of the $\bar{\partial}$-Neumann Laplacian. The focus is on inverse problems: how the geometry of a domain in several complex variables is determined by the spectrum of its $\bar{\partial}$-Neumann Laplacian. (Received February 14, 2011)

1070-32-298 **Marshall A. Whittlesey*** (mwhittle@csusm.edu), Department of Mathematics, California State University San Marcos, 333 S. Twin Oaks Valley Road, San Marcos, CA 92096. *Graphs of analytic functions in hull boundaries.* Preliminary report.

Let B_n be the open unit ball in $\mathbf{C}^n$, X a subset of $\partial B_n \times \mathbf{C}^m$, and (z_0, w_0) a point in $B_n \times \mathbf{C}^m$. We seek an analytic $f : B_n \to \mathbf{C}^m$ whose graph passes through (z_0, w_0) and has boundary in X. We find such a graph based on the ability to place (z_0, w_0) in the boundary of the polynomial hull of many subsets of X. (Received February 15, 2011)

1070-32-318 **Daisuke Suyama** and **Hiroaki Terao*** (hterao00@za3.so-net.ne.jp), Department of Mathematics, Hokkaido University, Sapporo, 060-0810, Japan. *The Shi arrangements and the Bernoulli numbers.*

The Shi arrangement was introduced by J.-Y. Shi in relation to the Kazhdan-Lustzig cells of affine Weyl groups. It is an affine deformation of the arrangement of the type A_ℓ. One of its remarkable properties is the fact that the Poincaré polynomial factors as $(t + \ell + 1)^\ell$. In particular, the number of chambers is equal to $(\ell + 2)^\ell$. Ch. Athanasiadis showed that the cone $\mathcal{A}$ of the Shi arrangement is a free arrangement, which explains why the Poincaré polynomial factors. He used the addition theorem to show the freeness. In this talk, we give an explicit formula for a basis for the derivation module $D(\mathcal{A})$ in terms of the Bernoulli numbers, which are proved to be inherent in the study of Shi arrangements. (Received February 15, 2011)

34 ► Ordinary differential equations

1070-34-15 **Dorian S Abbot*** (abbot@uchicago.edu), 5734 South Ellis Avenue, Chicago, IL 60637, **Mary Silber**, 2145 Sheridan Road, Evanston, IL 60208, and **Raymond T Pierrehumbert**, 5734 South Ellis Avenue, Chicago, IL 60637. *Using a Simple Mathematical Model to Understand Arctic Sea Ice Behavior in a Future Warmer Climate.*

Arctic sea ice is currently being lost at a rapid rate. This loss could continue linearly until there is no sea ice left or sea ice could exhibit nonlinear behavior, such as a collapse after crossing a nonlinear threshold or jumping between equilibria as a result of stochastic weather forcing. Eisenman and Wettlaufer (2009) developed a simple ODE model of seasonal variations in Arctic sea ice that allows us to get a handle on what sort of behavior we might expect. Their main conclusion was that summer sea ice loss shouldn't exhibit nonlinear threshold behavior but winter sea ice loss could. We extend their model to include changes in clouds and heat transport into the Arctic as sea ice is lost. We find nonlinear behavior is possible for summer sea ice loss, but that winter sea ice loss should be "more" nonlinear. These results appear to be consistent with those from highly complex global climate models. (Received November 21, 2010)

1070-34-22 **Anna M. Barry*** (annab@bu.edu), **Glen R. Hall** and **C. Eugene Wayne**. *Relative Equilibria of the (1+N)-Vortex Problem.*

We study relative equilibria of the $(1+N)$-vortex problem where N vortices have small, equal circulation and one vortex has large circulation. In the limit, the problem reduces to seeking critical points of a particular potential function defined on a circle. In contrast to the Newtonian $(1 + N)$-body problem, there are typically multiple

relative equilibria for both small and large N. Linear stability is also studied, and situations are found where there are no stable relative equilibria. (Received December 12, 2010)

1070-34-199 **Eric M Wahl***, Lincoln Laboratory, Massachusetts Institute of Technology, Lexington, MA 02420. *Estimating the future position uncertainty of an earth-bound satellite using the Clohessy-Wiltshire-Hill equations.*

Suppose we have an estimate of an Earth-orbiting object's state (position and velocity) and a measure of our uncertainty in this estimate in the form of a covariance matrix. We can propagate both the state and covariance by numerical integration of a differential equation which models drag and other perturbative forces, however propagating covariance matrices in such a manner can be very computationally intensive.

I will discuss a linearization of the two body problem, the Clohessy-Wiltshire-Hill (CWH) equations, and how they can be used to more efficiently propagate a covariance matrix. I will then quantify the accuracy of this linear approximation using simulated observations of the European Space Agency satellite Envisat. (Received February 11, 2011)

35 ► Partial differential equations

1070-35-4 **Natasa Sesum*** (natasas@math.rutgers.edu), 515 fourth street apt 402, Hoboken, NJ 07030, and **Panagiota Daskalopoulos** and **Ovidiu Munteanu**. *Solitons in geometric evolution equations.* Preliminary report.

We will discuss the importance of solitons in studying geometric evolution equations. We focus on the Yamabe flow and the Ricci flow. In the first part of the talk we will give the classification of Yamabe solitons in the locally conformally flat case. In the second part of the talk we will talk about the classification of shrinking Ricci solitons. (Received February 10, 2011)

1070-35-16 **David M. Ambrose***, 3141 Chestnut Street, Philadelphia, PA 19026, and **J. Douglas Wright**. *Some Existence Results for Equations with Degenerate Dispersion.*

Unlike equations with linear dispersion, such as the KdV or Benjamin-Ono equations, there is almost no existence theory for equations with degenerate dispersion, such as the Rosenau-Hyman compacton equations. We present a class of equations with degenerate dispersion for which we are able to establish a priori estimates in Sobolev spaces. In our various cases, these estimates lead to existence of either weak or strong solutions, either locally or globally in time. (Received November 29, 2010)

1070-35-43 **Muhammet Kurulay*** (muhammet.kurulay@uconn.edu), 33 stone ridge, Mansfield, CT 06250. *Analytic study on nonlinear fractional partial differential equations.*

In this study, we present a kind of analytical method homotopy analysis method (HAM) to obtain solution of nonlinear fractional partial differential equations.Analytical results validate the convergence and accuracy of the homotopy analysis method.The fractional derivative is described in the Caputo sense. Finally, the accuracy properties are demonstrated by some example. (Received December 22, 2010)

1070-35-57 **Luca Capogna*** (lcapogna@uark.edu), Department of Mathematical Sciences, 1 University of Arkansas, Fayetteville, AR 72701. *An Aronsson type approach to extremal quasiconformal mappings.*

In a joint work with A. Raich (U. of Arkansas) we study C^2 extremal quasiconformal mappings in space and establish necessary and sufficient conditions for a 'localized' form of extremality in the spirit of the work of G. Aronsson on absolutely minimizing Lipschitz extensions. We also prove short time existence for smooth solutions of a gradient flow of QC diffeomorphisms associated to the extremal problem. (Received January 20, 2011)

1070-35-79 **Timothy A Smith***, 600 S. Clyde Morris Blvd., ERAU math-LB 119, Daytona Beach, FL 32796. *on KdV and KP type equations with bounded initial data and introduction of a new dispersive term representing viscosity of the fluid.*

Various results are obtained for several equations derived from the KdV with addition of viscosity into the modeling and / or a weakly 2-d effect. Standard existence and uniqueness results are obtained through fixed point arguments; in addition, some results from numerical computation for constant initial data are presented in the appendix. (Received January 27, 2011)

1070-35-151 **Nestor Guillen*** (nguillen@math.utexas.edu) and **Russell Schwab** (rschwab@andrew.cmu.edu). *Aleksandrov-Bakelman-Pucci Estimates For Integro-Differential Equations.*

The Aleksandrov-Bakelman-Pucci (ABP) estimate is crucial in the regularity theory of fully non-linear second order elliptic equations. Its main feature is it controls pointwise values of solutions in terms of integral averages of the right hand side. We provide an extension of this estimate to non-local (i.e. integro differential) fully non-linear elliptic equations and discuss several of its consequences. One of the main issues dealt with is the current lack of non-local geometric equations such as Monge-Ampere. (Received February 07, 2011)

1070-35-180 **Longzhi Lin*** (lzlin@math.jhu.edu), Department of Mathematics, Johns Hopkins University, 3400 N Charles Street, BALTIMORE, MD 21218, and **Ling Xiao**. *Modified Mean Curvature Flow of Star-shaped Hypersurfaces in Hyperbolic Space.*

I will talk about my recent work on the modified mean curvature flow (MMCF) of star-shaped hypersurfaces in hyperbolic space with fixed prescribed asymptotic boundary at infinity. As an application, this recovers the existence and uniqueness of smooth complete hypersurfaces of constant mean curvature in hyperbolic space with prescribed asymptotic boundary at infinity, which was first shown by Guan and Spruck. This is joint with Ling Xiao of The Johns Hopkins University. (Received February 10, 2011)

1070-35-183 **Nam Q Le*** (namle@math.columbia.edu) and **Ovidiu Savin**. *Boundary regularity for minimizers of the Futaki invariant functional with constraints.*

We consider the Futaki invariant functional over convex functions, defined on a strictly convex domain in the Euclidean space and having prescribed Monge-Ampere measures. This functional arises in the study of the existence of Kahler metrics of constant scalar curvature on toric varieties. When the dimension is 2 and the Futaki invariant functional is K-stable, we show that its minimizers are $C^{1,\alpha}$ up to the boundary. One of the main tools in our proof is the localization property at the boundary for the Monge-Ampere equations. (Received February 10, 2011)

1070-35-196 **Zheng-Chao Han*** (zchan@math.rutgers.edu), Department of Mathematics, Rutgers University, Piscataway, NJ 08854, and **YanYan Li** (yyli@math.rutgers.edu), Department of Mathematics, Rutgers University, Piscataway, NJ 08854. *On the local solvability of the Nirenberg problem on $\mathbb{S}^2$.*

We present some results on the local solvability of the Nirenberg problem on $\mathbb{S}^2$. More precisely, an $L^2(\mathbb{S}^2)$ function near 1 is the Gauss curvature of an $H^2(\mathbb{S}^2)$ metric on the round sphere $\mathbb{S}^2$, pointwise conformal to the standard round metric on $\mathbb{S}^2$, provided its $L^2(\mathbb{S}^2)$ projection into the the space of spherical harmonics of degree 2 satisfy a matrix invertibility condition, and the ratio of the $L^2(\mathbb{S}^2)$ norms of its $L^2(\mathbb{S}^2)$ projections into the the space of spherical harmonics of degree 1 vs the space of spherical harmonics of degrees other than 1 is sufficiently small. (Received February 11, 2011)

1070-35-299 **Jun A Kitagawa*** (jun@Math.Princeton.EDU), Department of Mathematics, Fine Hall, Washington Road, Princeton, NJ 08542, and **Micah Warren**. *Regularity for the optimal transport problem with Euclidean distance squared cost on the embedded sphere.*

We consider regularity for Monge solutions to the optimal transport problem when the initial and target measures are supported on the embedded sphere, and the cost function is the Euclidean distance squared. Gangbo and McCann have shown that when the initial and target measures are supported on boundaries of strictly convex domains in $\mathbb{R}^n$, there is a unique Kantorovich solution, but it can fail to be a Monge solution. By using PDE methods, in the case when we are dealing with the sphere with measures absolutely continuous with respect to surface measure, we present a condition on the densities of the measures to ensure that the solution given by Gangbo and McCann is indeed a Monge solution, and obtain higher regularity as well. This is a joint work with Micah Warren. (Received February 15, 2011)

37 ► Dynamical systems and ergodic theory

1070-37-1 **Vitaly Bergelson*** (vitaly@math.ohio-state.edu), Department of Mathematics, Ohio State University,Columbus,OH 43210. *Ergodic Ramsey Theory: Dynamical Systems at the Service of Combinatorics and Number Theory.*

The lecture will be devoted to the presentation of some of the numerous and multifaceted connections which exist between Dynamics, Combinatorics and Number Theory. We will start with briefly reviewing the classical Poincare's recurrence theorem which appeared as Theorem I in Poincare's King Oscar Prize-winning memoir "Sur

le probleme des trois corps et les equations de dynamique" (1890). We will move then to the discussion of classical theorems in combinatorics, such as van der Waerden's and Szemeredi's theorems on arithmetic progressions, and describe Furstenberg's dynamical approach to their proofs. Furstenberg's ideas have led to exciting developments and we will discuss some of them, including the polynomial Szemeredi theorem, multiple recurrence theorems for general groups and the role of dynamical systems on nil-manifolds in the study of multiple recurrence. Some of the recent results rely heavily on methods of topological algebra in the Stone-Cech compactifications and we will review some of these methods. We will also discuss the ergodic underpinnings of the spectacular theorem of Green and Tao on arithmetic progressions in primes and its recent polynomial extension by Tao and Ziegler. (Received February 07, 2011)

1070-37-27 **Richard P. McGehee*** (mcgehee@umn.edu), School of Mathematics, University of Minnesota, Minneapolis, MN 55455. *An Ice-Albedo Feedback Model of Paleoclimate.*

The Earth undergoes long-term temperature cycles alternating between glacial and interglacial episodes. It is widely accepted that changes in the Earth's orbit and rotation axis cause variations in solar input which drive the glacial cycles. However, discrepancies between analysis of orbital forcing and analysis of the climate data imply the existence of nonlinear feedback mechanisms. One of these mechanisms is ice-albedo feedback which can be modeled as a dynamical system and which, when combined with the cycles in the orbital elements, resolves some of the discrepancies. (Received December 15, 2010)

1070-37-38 **Leonid A Bunimovich** and **Alex Yurchenko***, alex@yurchenko.org. *Non-asymptotic results in the theory of open dynamical systems.*

A natural question of how the survival probability depends upon a position of a hole was seemingly never addressed in the theory of open dynamical systems. We found that this dependency could be very essential. The main results are related to the holes with equal sizes (measure) in the phase space of strongly chaotic maps. Take in each hole a periodic point of minimal period. Then the faster escape occurs through the hole where this minimal period assumes its maximal value. The results are valid for all finite times (starting with the minimal period) which is unusual in dynamical systems theory where typically statements are asymptotic when time tends to infinity. It seems obvious that the bigger the hole is the bigger is the escape through that hole. Our results demonstrate that generally it is not true, and that specific features of the dynamics may play a role comparable to the size of the hole. The main tools that were used to prove these results came from the theory of combinatorics on words. Specifically, we considered counting problems in pattern avoidance in strings and autocorrelation function of strings. (Received December 20, 2010)

1070-37-51 **Canan Celik Karaaslanli*** (canan.celik@bahcesehir.edu.tr), Bahcesehir University, Dept of Mathematics and Computer Sciences., Istanbul, Turkey. *The stability and Hopf bifurcation for a predator–prey system with time delay.*

In this paper, we consider a predator-prey system with time delay where the predator dynamics is logistic with the carrying capacity proportional to prey population. We study the impact of the time delay on the stability of the model and by choosing the delay time s as a bifurcation parameter, we show that Hopf bifurcation can occur as the delay time s passes some critical values. Using normal form theory and central manifold argument, we also establish the direction and the stability of Hopf bifurcation. Finally, we perform numerical simulations to support our theoretical results. (Received January 11, 2011)

1070-37-91 **Tiancheng Ouyang** and **Zhifu Xie*** (zxie@vsu.edu), Department of Mathematics & Computer Science, P.O.Box 9068, Virginia State University, Petersburg, VA 23806. *Number of Collinear Central Configurations.*

The motion of celestial body is described by a system of second order differential equations and it is called n-body problem. A central configuration plays the essential role in understanding the global structure of solutions of the n-body problem. A central configuration is an arrangement of the initial positions of masses that leads to special families of solutions of the n-body problem. There are different understandings of equivalence of central configurations in collinear n-body problem and we call them *permutation equivalence* and *geometric equivalence* when we count the number of central configurations. In the permutation equivalence, Euler found three collinear central configurations and Moulton generalized to $n!/2$ central configurations for any given mass m in the collinear n-body problem under permutation equivalence. In particular, the number of central configurations becomes from 12 under permutation equivalence to 1 under geometric equivalence for four equal masses. The main result in this paper is the discovery of the explicit parametric expressions of the union H_4 of the singular surfaces in the mass space (four distinct positive masses) which decrease the number of collinear central configurations under geometric equivalence. (Received February 01, 2011)

1070-37-92 **Han Li*** (li.han@yale.edu), Yale University Mathematics Dept., New Haven, CT 06511. *Effective Limit Distribution of the Frobenius Numbers.*

The Frobenius number of a lattice point $\boldsymbol{a}$ with positive coprime coordinates, is the largest integer which can **not** be expressed as a non-negative integer linear combination of the coordinates of $\boldsymbol{a}$. Marklof showed in 2010 that the limit distribution of the Frobenius numbers is given by the distribution for the covering radius function of a random unimodular lattice. The aim of the talk is to discuss the reason of this phenomenon, and indicate how to obtain the rate of the convergence of the corresponding distribution functions. (Received February 01, 2011)

1070-37-111 **Jinxin Xue*** (jinxinxue@gmail.com), Rm 211, McAlister Building, Penn State University, State College, PA 16801. *Arnold diffusion in a planar 4-body problem.*

In this work, a model of planar 4-body problem is constructed to show the existence of Arnold diffusion. In the plane, we have the restricted planar circular 3-body problem(RPC3BP) formed by Sun, Jupiter and a massless asteroid. A fourth massive body is introduced to perturb the asteroid periodically. The result of the work is, the asteroid will have linear energy growth.

This underlying mechanism was proposed by Gelfreich and Turaev. Their mechanism is to exploit two hyperbolic periodic orbits and their heteroclinic intersections. One important feature of this mechanism is, the energy of the system has linear growth speed, which is very fast.

In the 4-body problem model, the mechanism is shown to work by studying the 2 Lyapunov periodic orbits surrounding the L_1, and L_2 Lagrangian points in the RPC3BP.

This is an example of Arnold diffusion in the a priori chaotic case. (Received February 03, 2011)

1070-37-127 **Lior Fishman*** (lfishman@brandeis.edu), 415 South St, Waltham, MA 02454. *Schmidt's game, friendly measures and exceptional sets on fractals.*

In this talk I shall describe new results regarding properties of certain sets on fractals.

In particular, a question we addressed in a recent joint paper with R. Broderick, Y. Bugeaud, D. Kleinbock and B. Weiss was the following: what is the Hausdorff dimension of numbers normal to no base on the Cantor ternary set?

As it turns out, this and other related questions, arising from number theory, dynamics and Diophantine approximation theory, can be solved utilizing Schmidt's game and properties of the class of friendly measures.

In order to highlight the main ideas in many of these proofs, I shall first introduce this game and reprove a slight modification of Schmidt's original result regarding badly approximable numbers, pointing out where generalizations have been made using modern ideas and techniques. (Received February 06, 2011)

1070-37-153 **Anatoly M. Vershik*** (vershik@pdmi.ras.ru), St.Petersbrug branch of Steklov Mathemartical, Institute of Russian Academy of Sciences, Fontanka 27, St.Petersburg, 191023, Russia. *Asymptotic theory of the admissible metrics in the measure spaces and scaling entropy.* Preliminary report.

We consider important class of the measurable etrics in the measure space an its evolution under the action of the measure preserving transformations. It happened that the main asymptotic properties of the orbits of metrics does not depend on the initial metric and consequently are the invariant of the transformations. Te first application of this ideas leads to the notion of scaling entropy and concerned to the generalization of the Kolmogorov entropy onto the case of zero entropy. This allow to study the scaling entropy of adic transformations and to give the criteria of the discreteness of the spectrum. There are many relations of this strategy with the old and new papers of the various authors. (Received February 08, 2011)

1070-37-181 **Araceli Bonifant*** (bonifant@math.uri.edu), Department of Mathematics, URI, Lippitt Hall, Room 200, 5 Lippitt Road, KIngston, RI 02881, **Jan Kiwi** (jkiwi@puc.cl), Facultad de Matematicas, PUC, Pontificia Universidad Catolica, Casilla 306, Correo 22, Sanntiago de Chile, Chile, and **John Milnor** (jack@math.sunysb.edu), Institute for Mathematical Sciences, Stony Brook University, Stony Brook, NY. *The period p curve, $\mathcal{S}_p$ for Cubic Polynomials.*

The parameter space $\mathcal{S}_p$ for monic centered cubic polynomial maps with a marked critical point of period p is a smooth algebraic curve whose genus increases rapidly with p. In this talk I will discuss the topology of $\mathcal{S}_p$. (Received February 10, 2011)

1070-37-192 **Hee Oh*** (heeoh@math.brown.edu). *Sphere packings and conformal metrics.*

Given a conformal metric on an open subset of the n-dimensional Euclidean space, we describe the local asymptotic distribution of a sphere packing invariant under geometrically finite hyperbolic groups. Concrete examples include many natural sphere packings of hyperbolic manifolds. (Received February 11, 2011)

1070-37-194 **Eric Bedford** and **Kyounghee Kim*** (kim@math.fsu.edu), Department of Mathematics, FSU, Tallahassee, FL 32306. *Linear Fractional Recurrences: Periodicities and Integrability.*

We consider k-step recurrences of the form $z_{n+k} = A(z)/B(z)$, where A and B are linear functions of $z_n, z_{n+1}, ...,$ z_{n+k-1}, which we call k-step linear fractional recurrences. The first Theorem in this paper shows that for each k there are k-step linear fractional recurrences which are periodic of period 4k. Among this class of recurrences, there is also the so-called Lyness process, which has the form $A(z)/B(z) = (a + z_{n+1} + z_{n+2} + ... + z_{n+k-1})/z_n$. The second Theorem shows that the Lyness process has quadratic degree growth. The Lyness process is integrable, and we discuss its known integrals. (Received February 11, 2011)

1070-37-198 **Patrick Ingram*** (pingram@math.uwaterloo.ca), Department of Pure Mathematics, University of Waterloo, 200 University Avenue West, Waterloo, Ontario N2L 3G1, Canada. *Post-critically finite polynomials.*

In classical holomorphic dynamics, rational self-maps of the Riemann sphere whose critical points all have finite forward orbit under iteration are known as post-critically finite (PCF) maps. A deep result of Thurston shows that if one excludes examples arising from endomorphisms of elliptic curves, then PCF maps are in some sense sparse, living in a countable union of zero-dimensional subvarieties of the appropriate moduli space (a result offering dubious comfort to number theorists, who tend to work over countable fields). We show that if one restricts attention to polynomials, then the set of PCF points in moduli space is actually a set of algebraic points of bounded height. This allows us to give an elementary proof of the appropriate part of Thurston's result, but it also provides an effective means of listing all PCF polynomials of a given degree, with coefficients of bounded algebraic degree (up to the appropriate sense of equivalence). (Received February 11, 2011)

1070-37-200 **Rick Moeckel*** (rick@math.umn.edu). *Finding periodic brake orbits in the isosceles three-body problem.*

I will describe an existence proof for a simple, periodic solution of the isosceles three-body problem. In addition to being periodic, it is also a brake orbit, i.e., the initial velocities of the bodies are all zero. This seems to be the simplest known solution with these properties. The proof is based on a shooting argument in the three-dimensional energy manifold of the system. (Received February 11, 2011)

1070-37-238 **Joseph Robert Galante*** (joepi@math.umd.edu), Department of Mathematics, Mathematics Building, University of Maryland, College Park, MD 20742-4015. *Estimating The Speed of Diffusion in the Restricted Circular Planar Three Body Problem.* Preliminary report.

We consider the dynamics of a Sun-Jupiter-Comet system and under some simplifying assumptions, construct a variational principle to show the existence of instabilities for the orbit of the comet. The explicit construction utilizes methods in the spirit of Mather's results as well as computer assistance to provide concrete estimates. The technique allows us to estimate the speed of diffusion of comets, i.e. come up with a realistic lower bound on time it takes a certain class of comets to exit the Solar system. (Received February 13, 2011)

1070-37-294 **Giulio Tiozzo*** (tiozzo@math.harvard.edu), **Claudio Bonanno**, **Carlo Carminati** and **Stefano Isola**. *Dynamics of continued fraction transformations and kneading sequences of unimodal maps.*

The continued fraction expansion and the binary expansion provide two of the most widely-used methods of description of a real number by means of a sequence of integers. By relating the two codings, we construct a correspondence between the parameter spaces of two families of one-dimensional dynamical systems, and discuss the "exceptional" parameters for these families. By means of this dictionary, one can recover results about the real slice of the Mandelbrot set, and the set of univoque numbers. (Received February 14, 2011)

1070-37-301 **Tim Austin*** (timaustin@math.brown.edu), Mathematics Department, Brown University, Box 1917, 151 Thayer St, Providence, RI 02912. *Some recent advances in Multiple Recurrence.*

In 1975 Szemerédi proved the remarkable combinatorial fact that any subset of the integers having positive upper density contains arbitrarily long arithmetic progressions. Shortly afterwards Furstenberg gave a new proof

of Szemerédi's Theorem using a conversion to an assertion of 'multiple recurrence' for probability-preserving systems, which he then proved using newly-developed machinery in ergodic theory.

Furstenberg's work gave rise to a new subdiscipline called 'Ergodic Ramsey Theory', which then found several further combinatorial applications. More recent work has provided a much more detailed picture of the structures that underlie this area of ergodic theory, and offered a clearer insight into the connections between this field and finitary approaches to the same results. I will describe a purely structural question within ergodic theory that has recently emerged from these efforts, and whose solution in some special cases gives a new approach to the multidimensional generalizations of multiple recurrence and Szemeredi's Theorem. (Received February 15, 2011)

1070-37-341 **Jimmy Tseng*** (tseng@math.ohio-state.edu), Department of Mathematics, Ohio State University, 231 West 18th Avenue, Columbus, OH 43210. *Markov partitions, nondense orbits, games, and number theory.*

Winning a certain game, played on a subset of some Euclidean space, allows us to determine the Hausdorff dimension of the subset.

Consider the orbit of a point under an expanding circle map. Using the game and (finite element) Markov partitions, I show that points whose orbits are nondense form a full Hausdorff dimension set. When the map is linear, this set has number-theoretical meaning.

Very recently, together with W. Mance, I have extended my result above to Lüroth expansions, which are analogous to continued fraction expansions. For this result, we deal with an infinite element Markov partition. (Received February 16, 2011)

39 ► Difference and functional equations

1070-39-103 **Frank J. Palladino*** (frank@math.uri.edu) and **Michael A. Radin** (michael.radin@rit.edu). *A bifurcation result for non-autonomous rational difference equations.* Preliminary report.

We study non-autonomous rational difference equations. Under the assumption of a periodic non-autonomous parameter, we show that a well known bifurcation result in the autonomous case is preserved. (Received February 02, 2011)

1070-39-107 **Gerry Ladas*** (gladas@math.uri.edu), Department of Mathematics, University of Rhode Island, Kingston, RI 02881. *Open Problems and Conjectures in Difference Equations.* Preliminary report.

We present some new results and we pose several open problems and conjectures on the global character of solutions of rational difference equations and systems of rational difference equations. We are interested in patterns of boundedness, invariants, global stability results, periodic solutions, convergence to periodic solutions, and periodic trichotomies. During the last two years with my collaborators and students we have discovered 15 patterns of boundedness for rational systems in the plane which (with a few conjectures about a small number of special cases) determine the boundedness character of each of the 2401 special cases of rational systems in the plane. These patterns offer a fertile area of research in the global character of solutions of rational difference equations and systems. (Received February 02, 2011)

1070-39-108 **Emmanouil Drymonis*** (mdrymonis@math.uri.edu), Department of Mathematics, University of Rhode Island, Kingston, RI 02881. *Patterns of Boundedness of Rational Systems in the Plane.* Preliminary report.

We present the patterns of boundedness of some rational systems in the plane. We establish easily verifiable necessary and sufficient conditions, explicitly stated in terms of the parameters of the systems, which determine the boundedness character of all special cases of the systems. Some global stability results are also presented. (Received February 02, 2011)

1070-39-172 **Gabriel Lugo*** (glugo@math.uri.edu), Department of Mathematics, 5 Lippitt Road, Kingston, RI 02881, and **Frank Palladino**. *Unboundedness Results For Fourth Order Rational Difference Equations.* Preliminary report.

New techniques are presented to exhibit unbounded solutions for a class of rational difference equations. These techniques are of particular relevance for equations of order greater than two. Resolution of conjectures, by Ladas et al., for a class of fourth order rational difference equations will be presented. (Received February 09, 2011)

1070-39-176 **Edward Grove**, **Gerasimos Ladas** and **Evelina G Lapierre***, elapierre@jwu.edu, and **Wirot Tikjha**. *On The Piecewise Linear System* $x_{n+1} = |x_n| + ay_n + b \quad , \quad y_{n+1} = x_n + c|y_n| + d$. Preliminary report.

We give a detailed analysis, complete with open problems and conjectures, of the global character of the solutions of the piecewise linear difference equations

$$\begin{cases} x_{n+1} = |x_n| + ay_n + b \\ \\ y_{n+1} = x_n + c|y_n| + d \end{cases}, \quad n = 0, 1, \dots$$

where the initial condition $(x_0, y_0) \in \mathbf{R}^2$ and the parameters $a, b, c, d \in \{-1, 0, 1\}$. (Received February 09, 2011)

1070-39-197 **Chris D. Lynd*** (chris_lynd@my.uri.edu), chris_lynd@my.uri.edu, RI. *Using Difference Equations to Extend Our Knowledge of Nested Radicals.*

The sequence

$$\{z_n\}_{n=1}^{\infty} = \{c_0\sqrt[r_1]{a_1}, c_0\sqrt[r_1]{a_1 + c_1\sqrt[r_2]{a_2}}, ..., c_0\sqrt[r_1]{a_1 + c_1\sqrt[r_2]{a_2 + ... + c_{n-1}\sqrt[r_n]{a_n}}}, ...\}$$

when defined, is denoted by the right nested root

$$c_0\sqrt[r_1]{a_1 + c_1\sqrt[r_2]{a_2 + c_2\sqrt[r_3]{a_3 + c_3\sqrt[r_4]{a_4 + ...}}}}$$

We consider right nested roots where $\{c_n\}_{n=0}^{\infty}$ and $\{a_n\}_{n=1}^{\infty}$ are periodic sequences of real numbers and $\{r_n\}_{n=1}^{\infty}$ is a periodic sequence of integers greater than or equal to two. We show that right nested roots of this form can be produced from solutions to a first-order difference equation $x_{n+1} = f(x_n)$ for $n = 1, 2, 3, ...$ where f is a continuous, monotone function.

We use the equilibrium points and periodic points of the difference equation, and their basins of attraction, to determine the convergence and limit points of the corresponding nested root. Our method of analysis differs from previous work and extends previous convergence results to rth roots, periodic parameters with an arbitrary period, and negative parameters. It also extends previous convergence results for left nested roots and can be applied to continued fractions with periodic parameters. (Received February 13, 2011)

1070-39-207 **Michael A. Radin*** (michael.radin@rit.edu), Rochester Institute of Technology, School of Mathematical Sciences, 85 Lomb Memorial Drive, Rochester, NY 14623, **Edward Grove** (grove@math.uri.edu), University of Rhode Island, Department of Mathematics, Kingston, RI 02881, **Kostrov Yevgeniy** (ykostrov@xula.edu), Xavier University of Louisiana, 1 Drexel Drive, New Orleans, LA 70125, and **Schultz Stephen**, Providence College, Department of Mathematics, 549 River Avenue, Providence, RI 02918. *On The Global Character of the solutions of the system:* $x_{n+1} = \frac{\alpha_1}{x_n + y_n} y_{n+1} = \frac{\alpha_2 + y_n}{B_2 x_n + y_n}$.

We investigate the global stability and the boundedness character of solutions of the system of rational difference equations:

$$\begin{cases} x_{n+1} = \frac{\alpha_1}{x_n + y_n} \\ \\ y_{n+1} = \frac{\alpha_2 + y_n}{B_2 x_n + y_n} \end{cases} n = 0, 1, \dots ,$$

with positive parameters and positive initial conditions. (Received February 11, 2011)

1070-39-233 **M Predescu*** (mpredescu@bentley.edu), Bentley University, Department of Mathematical Sciences, 175 Forest St., Waltham, MA 02452. *On a Nonlinear System of Difference Equations.*

We will investigate the dynamics and the global stability character of solutions of a nonlinear system of difference equations that appears in mathematical biology. This is joint work with N. Josephy and S. Woolford. (Received February 13, 2011)

1070-39-280 **Mustafa R.S. Kulenovic***, Department of Mathematics, University of Rhode Island, Kingston, RI 02881, and **Mehmed Nurkanovic**, Department of Mathematics, University of Tuzla, Tuzla, Bosnia-Herzegovina. *Global Behavior of a Two-dimensional Competitive System of Difference Equations with Stocking.*

We investigate the global dynamics of solutions of a competitive rational systems of difference equations in the plane:

$$x_{n+1} = \frac{b_1 x_n}{1 + x_n + c_1 y_n} + h, \quad y_{n+1} = \frac{b_2 y_n}{1 + c_2 x_n + y_n}, \quad n = 0, 1, \dots$$

where the parameters b_1, b_2, c_1, c_2 and h are positive numbers and the initial conditions x_0, y_0 are arbitrary non-negative numbers.

We show that the basins of attractions of different locally asymptotically stable equilibrium points are separated by the global stable manifolds of either saddle points or of non-hyperbolic equilibrium points. (Received February 14, 2011)

46 ► Functional analysis

1070-46-60 **Haodong Liang*** (hdliang@wpi.edu), 100 Institute Road, Mathematical Sciences Dept., Worcester Polytechnic Institute, Worcester, MA 01609. *Quasi-metric Functional Inequalities on the Snowflake Set.* Preliminary report.

We introduce a suitable quasi distance and a measure-valued gradient form (Lagrangian) on the snowflake set and prove scaled Poincaré and capacity inequalities on the quasi-metric balls of the set. It also shows that how the quasi-distance, the invariant Hausdorff measure and the Lagrangian are mutually related on that set. (Received January 20, 2011)

1070-46-74 **Richard M Aron*** (aron@math.kent.edu), Department of Mathematics, Kent State University, Kent, OH 44242. *Cluster Value Theorems for Banach algebras of analytic functions on the ball of a Banach space.*

We report on joint work with D. Carando, T. W. Gamelin, S. Lassalle, and M. Maestre.

Let B be the open unit ball of a complex Banach space X. In analogy with the standard setting, we let

$$H^\infty(B) = \{f : B \to \mathbb{C} \mid f \text{ is analytic and bounded on } B\},$$

and

$$A_u(B) = \{f : B \to \mathbb{C} \mid f \text{ is analytic and uniformly continuous on } B\}.$$

Both are Banach algebras with the sup norm. Let $\mathcal{A}$ be either algebra and set

$$\mathcal{M}(\mathcal{A}) = \{\varphi : \mathcal{A} \to \mathbb{C} \mid \varphi \text{ is a homomorphism}\}.$$

In the classical context, I. J. Schark proved the following cluster value theorem, which in fact is a weak version of the Corona Theorem: For a fixed $f \in H^\infty(D)$ and a fixed point $z_0 \in \overline{D}$,

$$\{w \in \mathbb{C} \mid \exists (z_n) \subset D \text{ such that } z_n \to z_0 \text{ and } f(z_n) \to w\} = \{\varphi(f) \mid \varphi(z) = z_0\}.$$

We describe a cluster value theorem in infinite dimensional context, extending Schark's result to certain Banach spaces such as $X = c_0$ and $X = \ell_2$. (Received January 25, 2011)

1070-46-75 **Manuel Maestre*** (manuel.maestre@uv.es), Departmento de Analisis Matematico, Universidad de Valencia, Doctor Moliner, 50, 46100 Burjasot, Valencia, Spain. *Fibers of the spectra of Banach algebras of analytic functions on the ball of a Banach space.*

Fibers of the spectra of Banach algebras of analytic functions on the ball of a Banach space

We report on joint work with R. M. Aron, D. Carando, T. W. Gamelin, and S. Lassalle.

We use the notation and terminology of the abstract of R. M. Aron.

It is clear that $b \rightsquigarrow \delta_b$ defines an inclusion of B into $\mathcal{M}(\mathcal{A})$, where $\delta_b \in \mathcal{M}(\mathcal{A})$ denotes evaluation at b. Further, for $\varphi \in \mathcal{M}(\mathcal{A})$, let $\pi(\varphi) = \varphi|_{X^*}$. Thus, $\pi(\mathcal{M}(\mathcal{A})) \subset X^{**}$. It is easy that $\pi(\delta_b) = b$ for all $b \in B$. But it turns out that the range of π is the whole $\overline{B^{**}}$, the closed unit ball of X^{**}, the topological bidual of X.

We discuss recent work on fibers $\pi^{-1}(b)$, where $b \in \overline{B^{**}}$. Unlike the classical situation, fibers $\pi^{-1}(b)$ over points of $\overline{B^{**}}$ can be trivial for boundary points b while having a rich structure and large cardinality over interior points. (Received January 25, 2011)

1070-46-93 **Rongwei Yang*** (ryang@math.albany.edu), 10 Harmony Court, Cohoes, NY 12047. *Banach algebra and Hyperplane Arrangements.*

A complex Banach algebra $\mathcal{B}$ is a complete normed algebra over the complex field $\mathbb{C}$. For a tuple $A = (A_1, A_2, ..., A_n)$ of elements in $\mathcal{B}$, properties of the linear sum $A(z) = z_1A_1 + z_2A_2 + ... + z_nA_n$ (called multiparameter pencil of A) is of interest in many areas of science. We define the projective spectrum $P(A)$ to be the collection of $z \in \mathbb{C}^n$ such that $A(z)$ is not invertible in $\mathcal{B}$. $P(A)$, as oppose to some classical notions of joint spectrum for tuples, enjoys some nice geometric and topological properties. An interesting example is the case when A is a commuting tuple, in which $P(A)$ turns out to be a union of hyperplanes. This talk examines this connection. We will see why infinite union of hyperplanes arises naturally, and we will also give another point of view on the Orlick-Solomon ideal. (Received February 01, 2011)

1070-46-185 **T. Tonev*** (tonevtv@mso.umt.edu), The University of Montana, Missoula, MT 59803.
Composition operators between subsets of function algebras.

This talk is based on a joint paper with E. Toneva. We expand the Banach-Stone theorem for non-linear isometries and also to non-unital function algebras. Let A and B be function algebras and A_1 be a dense subset of A. If $T\colon A_1 \to B$ is an isometry with a dense range, such that $\big\||Tf| + |Tg|\big\| = \big\||f| + |g|\big\|$ for all $f, g \in A$, and $T(ih_0) = i\,(Th_0)$, where $h_0 \in A_1$ does not vanish on the Choquet boundary δA of A, then T is a weighted composition operator on δB, i.e. there is a homeomorphism $\psi\colon \delta B \to \delta A$ and a continuous function $\alpha\colon \delta B \to \mathbb{C}$ so that $(Tf)(y) = \alpha(y)\, f\big(\psi(y)\big)$ for all $f \in A_1$ and $y \in \delta B$. If, in addition, A_1 is an algebra, then so is $\overline{\alpha}\, T(A_1)$ and $\overline{\alpha} \cdot T\colon A_1 \to \overline{\alpha}\, T(A_1)$ is an isometric algebra isomorphism. We show also that if A and B are function algebras, A_1 is a dense subset of A and $T\colon A_1 \to B$ is an isometry with a dense range in B such that $\big\||Tf| + |Tg|\big\| = \big\||f| + |g|\big\|$ for all $f, g \in A_1$ and preserves the peripheral spectra, then δB is homeomorphic to δA and T is a composition operator on δB. (Received February 10, 2011)

1070-46-220 **Alexander J. Izzo*** (aizzo@math.bgsu.edu). *Function algebras invariant under every self-homeomorphism.* Preliminary report.

We will present results concerning function algebras invariant under group actions inspired by a question raised by Ronald Douglas in connection with his work on a conjecture in operator theory due to William Arveson. In particular, we will answer, in suitably generalized form, the following question which could be posed in a beginning analysis course: If A is a uniformly closed algebra of continuous complex-valued functions on a closed ball in Euclidean space such that A contains the constants and separates points, and if for each self-homeomorphism h of the closed ball and each function f in A the composite function $f \circ h$ is also in A, must then A contain every continuous complex-valued function on the closed ball? (Received February 12, 2011)

1070-46-306 **Irina N Seceleanu*** (iseceleanu@bridgew.edu), Department of Mathematics & Computer Science, Bridgewater State University, 131 Summer Street, Bridgewater, MA 02325. *How an orbit with a single limit point induces a dense orbit.*

Given a continuous linear operator T on a Hilbert space H we denote the orbit of a vector x in H by $Orb(T, x) = \{x, Tx, T^2x, \ldots\}$. There are many examples of such operators that possess a dense orbit $Orb(T, x)$ in H amongst which we count the adjoints of multiplication operators. In this talk we show that the adjoints of multiplication operators exhibit a rather remarkable property, namely if an operator has an orbit with a single non-zero limit point it will also possess a dense orbit. In other words, for the adjoint of a multiplication operator having an orbit with one non-zero limit point is equivalent to having an orbit with every vector as a limit point. (Received February 15, 2011)

1070-46-319 **Sarah E Wright*** (swright@holycross.edu), Mathematics and Computer Science Department, College of the Holy Cross, 1 College Street, Worcester, MA 01610. *Graph Algebras, Aperiodicity, and Condition (F).*

The condition "every cycle has an entry" first appeared in the literature in Kumjian, Pask, and Raeburn's paper on Cuntz-Krieger algebras of directed graphs, where it was called Condition (L). It provides a necessary condition for simplicity of the associated graph algebra. This condition has been generalized to aperiodicity conditions in the theory of topological graphs (Katsura), k-graphs (Kumjian, Pask), and the unifying theory of topological k-graphs (Yeend). We'll discuss the details of these generalizations as well as the theorems associated with them. We'll then introduce a Condition (F) on the finite paths of a topological k-graph that is equivalent to the corresponding aperiodicity condition. Hence we obtain a condition which is much easier to check than the aperiodicity of infinite paths, which we'll explore through some examples. (Received February 15, 2011)

1070-46-339 **Stuart J Sidney*** (stuart.sidney@uconn.edu), University of Connecticut, Department of Mathematics, Unit 3009, Storrs, CT 06269-3009. *An introduction to real function algebras.*

If X is a compact Hausdorff space and τ is a self-homeomorphism of X such that $\tau \circ \tau$ is the identity map, a *real function algebra* A on (X, τ) is a uniformly closed point-separating unital real algebra of complex-valued functions f on X that satisfy $\overline{f \circ \tau} = f$; the prototypical example is the real subalgebra of the disc algebra that consists of functions f such that $f(\overline{z}) = \overline{f(z)}$, with complex conjugation on the unit disc as τ. The study of real function algebras, while several decades old, is still in its infancy compared to the study of complex function algebras (or *uniform algebras*), and much of the existing work consists of trying to find real versions of complex results, often by means of a process of complexification. The talk will attempt to give a small sample of some basic results and how complexification is used to prove a few of them.

Program for future research by interested parties: Find instances in which complexification can be used in the opposite direction, beginning with a direct proof in real function algebras of some result, then obtaining a corresponding result in complex function algebras. (Received February 15, 2011)

47 ► Operator theory

1070-47-63 **Don Hadwin*** (don@unh.edu), Math Dept UNH, Durham, NH 03824. *Some results relating complex analysis and operator theory.* Preliminary report.

This talk will be a brief survey of some of my past and current research in operator theory involving complex analysis. (Received January 22, 2011)

1070-47-203 **D. Drissi*** (drissi@sci.kuniv.edu.kw), Dept. of Mathematics, Kuwait University, P.O. Box 5969, safat 1306 Kuwait, Kuwait. *On m-idempotent operators and the invariant subspace problem.* Preliminary report.

We consider the resolvent algebra $R_A = \{T \in \mathcal{L}(\mathcal{X}) : \sup_{\Updownarrow \geq \prime} \|(\infty + \Updownarrow \mathcal{A})\mathcal{T}(\infty + \Updownarrow \mathcal{A})^{-\infty}\| < \infty\}$. It is shown that R_A possess non-trivial invariant subspaces when A is an m-idempotent operator. This assertion becomes stronger than the existence of a hyper-invariant subspace for R_A whenever $R_A \neq \{A\}'$. Using classical theorems on growth of analytic functions a complete characterization of the algebra R_A when A is an m-idempotent operator is given. (Received February 15, 2011)

49 ► Calculus of variations and optimal control; optimization

1070-49-44 **Yang Liu*** (yliu@marlboro.edu), Marlboro College P.O. Box A 2582 South Road, Marlboro, VT 05344. *Lower Rank Approximation: A Generalization of Schmidt-Mirsky Theorem and Algorithms.*

We study the optimal approximation of linear operators, especially, the linear operator on ℓ_p-space. Considering the generalized singular values, we prove an extension of Schmidt-Mirsky theorem. The results can be applied to matrix completion and sparse matrix recovery. (Received December 23, 2010)

51 ► Geometry

1070-51-18 **Brandon M Rowekamp*** (browekam@nd.edu). *The Geometry of Planar Pixelations.* Preliminary report.

In a pixelated plane (with pixels of size r) we consider the region X_r filled by the pixels that touch a given semialgebraic set X. I will explain how to associate to X_r a planar PL region Y_r so that as r goes to 0 the normal cycle of Y_r converges in the sense of currents to the normal cycle of X_r. This proof is based on a scanning technique inspired by Morse Theory coupled with some curvature estimates going back to a classical work of J. Milnor. (Received December 14, 2010)

1070-51-126 **Andrew O. Furnas*** (andrew_furnas@brown.edu), 69 Brown St. Box 4638, Providence, RI 02912. *Understanding the Drape of Woven Fabrics.*

The goal of this research is to use techniques from continuous and discrete differential geometry to better understand the drape of woven fabric. For example, why does twill-woven cotton (denim jeans) drape differently than plainly woven cotton (most dress shirts). Why do shoulder seams have to exist in woven shirts, but one can knit a sweater with no seams at all? Most models for the draping of flexible materials make the simplifying assumption that the material is isotropic; real fabric is highly anisotropic. These investigations date back to Pafnuty Chebyshev, who in 1878 he defined what are now known as Chebyshev nets. These are parametrizations of surfaces in 3-space which have unit length partial derivatives in each of the coordinate directions. This corresponds to a piece of plainly woven fabric where the fibers themselves are inextensible. We are now taking a discrete approach by building a fiber-based model where a discrete differential geometric model for an elastic rod is woven to form a piece of fabric, and then draped. This is inspired by Simulating Knitted Cloth at the Yarn Level by Kaldor, James and Marschner (2008). The fiber model itself builds from the work of Max Wardetzky and his collaborators on Discrete Elastic Rods (2008). (Received February 05, 2011)

1070-51-135 **Bianca Santoro*** (bsantoro@ccny.cuny.edu), NY 10032. *Complete Kahler Ricci-flat metrics on resolutions of singularities.*

We will discuss some existence results for complete Calabi-Yau metrics on crepant resolutions of singularities, and as an application, build simple examples of Ricci-flat manifolds. (Received February 07, 2011)

1070-51-205 **Ian P Biringer***, 84 Nash St, New Haven, CT 06511, and **Juan Souto**. *Geometric consequences of algebraic rank in hyperbolic 3-manifolds.*

Mostow's rigidity theorem states that a closed hyperbolic 3-manifold M is determined up to isometry by the algebra of its fundamental group. We will discuss how the geometry of M is constrained by the minimal number of elements needed to generate its fundamental group; this invariant is called the (algebraic) rank of M. In particular, we will explain how M can be decomposed into a number of geometric building blocks such that the complexities of the blocks and of the decomposition depend only on M's algebraic rank and on a lower bound for M's injectivity radius.

Joint with Juan Souto. (Received February 11, 2011)

1070-51-210 **Martha P. Dussan Angulo***, Rua do matao, 1010, cidade universitaria, Sao Paulo, sao paulo 05508-090, Brazil, and **Martin Magid** (mmagid@wellesley.edu), Department of Mathematics, Wellesley college, Wellesley, MA 02458. *The projective or split-quaternionic models: Applications to Lorentzian hypersurfaces with certain curvature conditions.*

The projective or split-quaternionic models are used to obtain informations of the geometry of Lorentzian surfaces or hypersurfaces in certain ambient spaces. For instance, using the projective model we consider conformally flat Lorentzian hypersurfaces in the conformal compactification of $\mathbb{R}_1^{n+1}$, the projetivized light cone $\widehat{\mathbb{R}}_1^{n+1} \subset \mathbb{R}P^{n+2}$ induced from $\mathbb{R}_2^{n+3}$. For this case, we give a Lorentz version of the classification theorem of Cartan, in terms of branched channel hypersufaces for $n \geq 4$, and for $n = 3$, in terms the conformal fundamental forms were closed. For hypersurfaces whose shape operator has complex eigenvalues, we give a necessary condition to be conformally flat in terms of local integrability of distributions. (Received February 12, 2011)

1070-51-215 **Brittany P. Baker*** (bbaker@smcvt.edu), **Patrick Dukes**, **Elias Halloran**, **Anne Ho**, **Audrey Hubbard**, **Alexander James**, **Victoria McCoy** and **Robert Rumely**. *The Origami Box Problem.* Preliminary report.

The Origami Box Problem: What is the largest volume that can be enclosed by folding a square sheet of paper, one unit on a side, into a closed box?

We consider different origami boxes with increasing volumes in our attempt to find the maximal volume of an origami box. We have not solved this problem; as will be seen, a solution would require a deep understanding of curved paper surfaces. However, we analyze a series of designs with larger and larger volumes, and we identify a class of designs, which we call Inflated Sealed Sacks, to which the optimal design likely belongs. We believe that our best design is within a few percent of the optimum.

After doing this research we found significant related work done under similar names, "Paper Bag Problem" or "Tea Bag Problem".

We finish with a few related open questions in origami, including our own origami cup problem. **The Origami Cup Problem:** What is the largest possible volume of a cup folded from a square sheet of paper, one unit on a side? (Received February 12, 2011)

1070-51-330 **Ren Guo*** (guoxx170@umn.edu), Vincent Hall, 206 Church st. SE, Minneapolis, MN 55455. *Inversive distance circle packings and hyperbolic volume.*

A Euclidean or hyperbolic circle packing on a triangulated closed surface with prescribed inversive distance is determined by its cone angles. It is established by using a variational principle whose energy functional is related to the volume of some hyperbolic polyhedra. (Received February 15, 2011)

52 ► Convex and discrete geometry

1070-52-13 **Satyan Devadoss*** (satyan.devadoss@williams.edu), **Timothy Heath** and **Cid Vipismakul**. *Deformations of bordered Riemann surfaces.*

We consider the moduli space of Riemann surfaces with boundary and marked points. Such spaces appear in open-closed string theory, particularly with respect to holomorphic curves with Lagrangian submanifolds. We consider a combinatorial framework to view the compactification of this space based on the pair-of-pants decomposition of the surface, relating it to the well-known phenomenon of bubbling. Our main result classifies all such spaces that can be realized as convex polytopes. A new polytope is introduced based on truncations of cubes,

and its combinatorial and algebraic structures are related to generalizations of associahedra and multiplihedra. (Received November 15, 2010)

1070-52-217 **Lily Du**, **Jessica Lord** and **Micaela Mendlow*** (mmendlow@gmail.com), Dept. Mathematics & Statistics, Smith College, Northampton, MA 01063, and **Emily Merrill**, **Joseph O'Rourke**, **Viktoria Pardey**, **Rawia Salih** and **Stephanie Wang**.
Solid-Coloring Objects Built From Rectangular Bricks. Preliminary report.

Define a *brick* as a rectangle in 2D, a rectangular box in 3D, and the natural generalization to $\mathbb{R}^d$. An *object built from bricks* is a connected collection of bricks glued together whole-face-to-whole face. A *solid-coloring* of such an object colors each brick so that no two bricks that share a face have the same color. In $\mathbb{R}^2$, objects built from square bricks are 2-colorable, and objects built from rectangle bricks are 3-colorable. In $\mathbb{R}^3$, objects built from cube bricks are again 2-colorable, but we have only proved that objects built from rectangular-box bricks are 4-colorable, although we have no example that needs more than 3 colors. We will report on progress proving that special classes of 3D objects built from bricks are 3-colorable, and on generalizations to other brick shapes and to higher dimensions. (Received February 12, 2011)

1070-52-260 **Jay Griffiths*** (jgriffit@smith.edu), Box 6927, Smith College, Northampton, MA 01063, and **Allison Reed-Harris** and **Rebecca Terry**. *Geometry of the Boundary configurations in a Phyllotaxis model.* Preliminary report.

Phyllotaxis is the study of the spiral arrangements in plants. These spirals most often come in two sets, whose numbers are consecutive Fibonacci numbers. We explore the set of initial conditions in a simple two-postulate dynamic-geometric model of Phyllotaxis. We focus on the stability question and in the geometry of the boundary between Fibonacci and Lucas configurations. (Received February 14, 2011)

1070-52-327 **Graham Denham**, **Hal Schenck**, **Mathias Schulze** and **Max Wakefield*** (wakefiel@usna.edu), 572-C Holloway Rd, US Naval Academy, Department of Mathematics, Annapolis, MD 21402, and **Uli Walther**. *On syzygies of the Jacobian ideal of a hyperplane arrangement.*

Let A be hyperplane arrangement with defining polynomial f. The Jacobian ideal $J(A)$ is the ideal generated by all partial derivatives of f. The set of zeros of $J(A)$ is the singular locus of A and, by a result of Terao, $J(A)$ is a Cohen-Macaulay ideal if and only if the module of logarithmic derivations is free. In this presentation we will study some intricate algebraic properties of $J(A)$. We will give a new algebraic criterion for freeness based on embedded primes of the Jacobian ideal and the projective dimension of the module of logarithmic 1-forms. We will conclude with an investigation of some graphic and generic arrangements. (Received February 15, 2011)

53 ► Differential geometry

1070-53-29 **Taechang Byun*** (tcbyun@math.ou.edu), Department of Mathematics, University of Oklahoma, Norman, OK 73019, **Kyeonghee Jo** (khjo@mmu.ac.kr), Division of Liberal Arts and Sciences, Haeyangdaehang-Ro 91, Mokpo, Jeolanamdo 530-729, South Korea, and **Kyung-Bai Lee** (kblee@math.ou.edu), Department of Mathematics, University of Oklahoma, Norman, OK 73019. *$SO(n)\backslash SO_0(n,1)$ has positive curvatures.*

The Lie group $\mathrm{SO}_0(n,1)$ has the left-invariant metric coming from the Killing-Cartan form. The maximal compact subgroup $\mathrm{SO}(n)$ of the isometry group acts from the left. The geometry of the quotient space of the homogeneous submersion $\mathrm{SO}_0(n,1) \to \mathrm{SO}(n)\backslash\mathrm{SO}_0(n,1)$ is investigated. The space is expressed as a warped product. Its group of isometries, sectional curvatures, and geodesics are calculated. (Received December 15, 2010)

1070-53-49 **Ramesh Sharma*** (rsharma@newhaven.edu), 300 Boston Post Rd., West Haven, CT 06516, and **Amalendu Ghosh**. *Non-trivial Ricci solitons on 3-D Sasakian manifolds and their obstruction to compactness.*

We show that, if a 3-dimensional Sasakian metric is a non-trivial Ricci soliton, then it is expanding and homothetic to the standard Sasakian metric on the Heisenberg group nil^3. We also show that the potential vector field leaves the characteristic vector field and the fundamental collineation invariant (upto a constant multiple). Finally, we will point out that the Ricci soliton would pose as an obstruction to the compactness of the Sasakian manifold. (Received January 05, 2011)

1070-53-72 **Ovidiu Munteanu***, Mathematics Department, Columbia University, New York, NY 10027. *Rigidity results for complete noncompact manifolds.*

I will talk about recent characterizations of the hyperbolic and complex hyperbolic spaces by their bottom of spectrum of the Laplace operator acting on functions. (Received January 24, 2011)

1070-53-117 **Rachelle C DeCoste** (decosterachelle@wheatoncollege.edu), Department of Mathematics and Computer Scienc, Wheaton College, Norton, MA, **Lisa DeMeyer*** (demey1la@cmich.edu), Department of Mathematics, Pearce 214, Central Michigan University, Mount Pleasant, MI 48859, and **Maura B Mast** (maura.mast@umb.edu), Department of Mathematics, Universiy of Massachusetts Boston, Boston, MA. *Characterizations of Heisenberg-like Lie algebras.*

Heisenberg-like Lie algebras were introduced by Gornet-Mast (2000) and are a generalization of Heisenberg type Lie algebras. We generalize results on Heisenberg type Lie algebras to obtain multiple characterizations of the Heisenberg-like property. In addition, infinite families of examples of Lie algebras which are Heisenberg-like, but not Heisenberg type, will be presented. (Received February 04, 2011)

1070-53-136 **Scott D. Pauls*** (scott.pauls@dartmouth.edu), 6188 Kemeny Hall, Dartmouth College, Hanover, NH 03755. *Minimal surfaces and models of the visual cortex.*

In 2004, G. Citti and A. Sarti provided a link between the minimal surface problem in sub-Riemannian model spaces and the disocclusion problem solved in the primary visual cortex. This provided a direct link between the growing literature on minimal surfaces in sub-Riemannian Lie groups and a physical problem in neuroscience.

In this talk, I will first discuss both the basic results in minimal surface theory in the so-called Carnot groups (sub-Riemannian nilpotent Lie groups) and the connection with the visual cortex. Second, I will demonstrate how mathematical results translate into neuroscience results through an analysis of certain optical illusions. (Received February 07, 2011)

1070-53-138 **Andrew A Cooper*** (coope106@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824. *Smooth singularity models for the Lagrangian mean curvature flow.*

We use a rescaling technique which produces smooth singularity models for the Lagrangian mean curvature flow. We will show that for any compact Lagrangian mean curvature flow, the first time singularity is modeled by either an exact, zero-Maslov-class Lagrangian flow, or a monotone Lagrangian flow, depending on the type of the singularity. (Received February 07, 2011)

1070-53-149 **Marisa C Zemsky*** (MCZems11@holycross.edu). *Isometries Of Geometric Spaces.*

With attempts to prove the parallel postulate in Euclidean geometry, ideas emerged about the existence of non-Euclidean geometries such as spherical geometry and hyperbolic geometry. Professor Cecil and I studied the isometry groups in the Euclidean plane, the sphere, and the hyperbolic plane. In order to understand the group of isometries, we first studied how geometry on the Euclidean plane is defined using linear algebra. Then we studied transformations that can be obtained as a product of a finite number of reflections: the identity transformation, reflections, translations, rotations, and glide reflections. We proved that in the E^2, every isometry, i.e., an onto mapping T from E^2 to itself that preserves distance, must be one of these types of transformations.

We continued our research by analyzing spherical geometry. Using our knowledge of E^2 we were able to study transformations on the sphere as well. Similar transformations to those in the Euclidean space are defined on the sphere. We proved our main theorem in S^2: For every isometry T_0 of S^2 there is an orthogonal transformation T coinciding with T_0 on S^2. By proving this we were also able to prove that every isometry of S^2 is one of the five transformations we studied. (Received February 07, 2011)

1070-53-152 **Meera G Mainkar*** (mainkar@dartmouth.edu), Department of Mathematics, Dartmouth College, Hanover, NH 03755. *Automorphisms of 2-step nilpotent Lie groups associated with graphs.*

We will associate a 2-step nilpotent Lie group with a simple graph. We will compute the automorphism group of these type of 2-step nilpotent Lie groups. This work was done with S. G. Dani. (Received February 07, 2011)

1070-53-154 **Rachelle C DeCoste*** (decoste_rachelle@wheatoncollege.edu), 26 East Main Street, Wheaton College, Department of Mathematics and Computer Sci, Norton, MA 02766, and **Lisa DeMeyer** (demey1la@cmich.edu), Department of Mathematics, Pearce 214, Central Michigan University, Mount Pleasant, MI 48859. *Totally geodesic subalgebras in 2-step nilpotent Lie algebras.* Preliminary report.

We generalize P. Eberlein's (1994) results on totally geodesic subalgebras of nonsingular 2-step nilpotent Lie algebras to include the singular case. Results to be discussed include the complete description of all totally geodesic submanifolds of a 2-step nilpotent Lie algebra, the decomposition of any totally geodesic submanifold, and sufficient conditions for a totally geodesic submanifold to be a totally geodesic subalgebra. Several examples will be given. (Received February 08, 2011)

1070-53-161 **Meng Zhu*** (mez206@lehigh.edu), 14 E. Packer Ave., Department of Mathematics, Lehigh University, Bethlehem, PA 18015. *On linear stability of compact Ricci solitons.* Preliminary report.

In his celebrated work, G. Perelman discovered two important functionals, the $\mathcal{F}$ and the $\mathcal{W}$ functional, which are monotone along steady and shrinking Ricci solitons respectively. Later on, M. Feldman, T. Ilmanen and L. Ni introduced so called $\mathcal{W}_+$ functional which has similar monotonicity on expanding Ricci solitons. In this talk, we are going to present the second variations of these functionals and investigate the linear stability of compact Ricci flat, negative Einstein, and gradient shrinking Ricci solitons. (Received February 08, 2011)

1070-53-165 **Stanley S Chang*** (schang@wellesley.edu), Mathematics Department, 106 Central Street, Wellesley College, Wellesley, MA 02481. *Positive Scalar Curvature in Noncompact Manifolds.* Preliminary report.

Since the work of Gromov-Lawson and Schoen-Yau, much research has been done on compact manifolds and the conditions under which they can maintain a Riemannian metric of positive scalar curvature. Efforts in the last twenty years have uncovered some interesting sufficient conditions but a complete characterization of so-called positive manifolds has not been found. In the context of noncompact manifolds, the positive scalar curvature problem has revealed some unusual phenomena that highlights the varied structures in these spaces. (Received February 08, 2011)

1070-53-216 **Tracy L Payne*** (payntrac@isu.edu), Department of Mathematics, Idaho State University, 921 S. 8th Ave., Stop 8085, Pocatello, ID 83209-8085. *Geometric Invariants for Nilmanifolds.*

We review known geometric invariants for nilmanifolds (there aren't many). We present two new geometric invariants that will distinguish two nilmanifolds having conjugate Ricci endomorphisms. (Received February 12, 2011)

1070-53-223 **Mihai Bailesteanu*** (mb452@cornell.edu), 301 Maple Ave, Apt D3, Ithaca, NY 14850. *Heat equation under the Ricci flow - old and new.*

We will discuss various Li-Yau type gradient estimates of the solution of the heat equation on a manifold evolving under Ricci flow. We consider both the case where the manifold is a complete manifold without boundary and the case where M is a closed manifold. Harnack inequalities follow there-from. We will also present some lower bounds for the heat kernel, involving Sobolev imbedding constants. (Received February 12, 2011)

1070-53-229 **Jeffrey L Jauregui*** (jauregui@math.upenn.edu). *Nonnegative scalar curvature on compact manifolds with boundary.*

We consider the problem of realizing given geometric data on the 2-sphere as the boundary of a compact Riemannian 3-manifold of nonnegative scalar curvature. By perturbing the boundary data, we construct a new definition of quasi-local mass, which may be of interest for its tendency to vanish on static vacuum metrics. (Received February 13, 2011)

1070-53-236 **Gideon Maschler*** (gmaschler@clarku.edu), Dept.of Mathematics and Computer Science, Clark University, Worcester, MA 01610. *Scalar Curvature and holomorphy potentials.* Preliminary report.

We examine Kähler metrics on compact manifolds which satisfy a generalization of Calabi's extremal metric condition. The requirements considered are that the scalar curvature is a function of a potential for a holomorphic vector field; or, that such a function, when multiplied by a function of the scalar curvature, yields a second holomorphy potential. We give examples, and a non-existence result for a particular family of metrics. (Received February 13, 2011)

1070-53-247 **Brett Lawrence Kotschwar*** (brett.kotschwar@aei.mpg.de), MPI for Gravitational Physics, Am Mühlenberg 1, Golm, D-14476. *Ricci flow and the holonomy group.*

We prove that the restricted holonomy group of a complete smooth solution to the Ricci flow of uniformly bounded curvature cannot spontaneously contract in finite time; it follows then from existing results that the holonomy group is exactly preserved by the equation. The non-contraction of holonomy has some geometric consequences, among them that $g(T)$ can only be Kähler or locally reducible (as a product) if the same is true of $g(t)$ at times $t < T$. We reduce the problem to one of backwards uniqueness for a certain coupled PDE-ODE system through the interpretation of the evolution equations of certain quantities derived from the metric in terms of the natural Lie bracket on two-forms. The backwards uniqueness of this system then follows from a earlier general result of the author. As the estimates for this result measure – and, in principle, limit – the rate at which the curvature operator can asymptotically "acquire" null directions, we have hope that these estimates (or improvements thereof) may have application in future work to analysis up to and including the singular time. (Received February 14, 2011)

1070-53-250 **Fernando Galaz-Garcia*** (f.galaz-garcia@uni-muenster.de) and **Martin Kerin**. *Isometric circle actions on simply-connected 4-manifolds with nonnegative curvature.*

The classification of simply-connected 4-manifolds with nonnegative sectional curvature remains an open problem. These manifolds have been classified, however, under the additional assumption of an isometric circle action. In this talk I wil discuss the classification of the possible circle actions on these manifolds. (Received February 14, 2011)

1070-53-263 **Thalia D. Jeffres*** (jeffres@math.wichita.edu), **Klaus Kirsten** and **Tianshi Lu**. *Zeta Function on a Surface of Revolution.* Preliminary report.

On a compact Riemannian manifold (M^n, g) with boundary, and taking Dirichlet boundary conditions, the zeta function of the Laplacian is given by

$$\zeta(s) = \sum_{\lambda_k \in \mathrm{Spec}(\Delta)} \lambda_k^{-s}.$$

This is convergent for complex values of s having real part greater than $n/2$. However, much information of geometric and physical significance is contained in extensions of $\zeta(s)$ to complex values of s lying outside this region.

On a compact surface of revolution, with Dirichlet boundary conditions, we are able to find formulas for the values of the holomorphic extension of the zeta function and its derivative at $s = 0$. These surfaces are geometrically interesting enough to exhibit the features typically contained in such expressions, while at the same time the rotational symmetry allows some explicit calculations. (Received February 14, 2011)

1070-53-272 **Christopher L. Rogers*** (chris@math.ucr.edu), Department of Mathematics, University of California, Riverside, 900 University Ave., Riverside, CA 92521. *L_∞-algebras from higher symplectic geometry.*

Higher analogues of algebraic and geometric structures studied in symplectic geometry naturally arise on manifolds equipped with a closed non-degenerate form of degree > 2. Traditionally, these "multisymplectic" manifolds have been used to describe classical field theories. In this talk, I will first explain how a multisymplectic manifold gives an L_∞-algebra of "Hamiltonian" differential forms, just as a symplectic manifold gives a Poisson algebra of functions. I will then describe how to prequantize these manifolds and, within this context, sketch the relationship between the L_∞-algebra of Hamiltonian forms and the Roytenberg-Weinstein L_∞-structure on Courant algebroids. (See arXiv:1005.2230 and arXiv:1009.2975 for more details.) (Received February 14, 2011)

1070-53-279 **Mark G Walsh*** (walsmark@math.oregonstate.edu). *Understanding the space of positive scalar curvature metrics.*

A great deal is known about the problem of whether or not a smooth manifold admits a metric of positive scalar curvature (psc-metric). Far less is known about the topology of the space $R^+(M)$ of psc-metrics on a given smooth manifold M (or the corresponding moduli spaces). In this talk, I will briefly discuss the status of this problem before describing some new techniques for constructing interesting families of psc-metrics. One application of these techniques (joint work with Botvinnik, Hanke and Schick) is to show that certain moduli spaces of psc-metrics have non-trivial higher homotopy groups. (Received February 14, 2011)

1070-53-285 **Catherine E Searle*** (csearle@matcuer.unam.mx) and **Fernando Calaz-Garcia**. *Nonnegatively curved 5-manifolds of almost maximal symmetry rank.*

We consider simply-connected, non-negatively curved Riemannian manifolds of dimension 5 admitting an isometric (almost) effective 2-torus action. (Received February 14, 2011)

1070-53-322 **Craig J. Sutton*** (craig.j.sutton@dartmouth.edu), Dartmouth College, Department of Mathematics, Hanover, NH 03755. *Hearing the moments of inertia of a rigid body.*

It is an interesting question to determine whether certain special classes of metrics can be distinguished by the spectrum of the Laplacian. For example, one might wonder whether symmetric spaces of the compact type (i.e., symmetric spaces of nonnegative curvature without a euclidean factor) can be distinguished from all other manifolds via the spectrum. In this talk we will discuss an approach to this problem and then apply it to a special case which has a physical interpretation. (Received February 15, 2011)

1070-53-326 **Craig J. Sutton*** (craig.j.sutton@dartmouth.edu), Dartmouth College, Department of Mathematics, Hanover, NH 03755, and **Carolyn Gordon** (carolyn.s.gordonn@dartmouth.edu), Dartmouth College, Department of Mathematics, Hanover, NH 03755. *Spectral isolation of naturally reductive metrics on simple Lie groups.*

This talk is motivated by the problem of determining the extent to which symmetric spaces of the compact type (e.g., spheres and semi-simple Lie groups with bi-invariant metrics) are spectrally determined. We recall that naturally reductive metrics are the homogeneous metrics that in some sense are most similar to symmetric metrics. We then show that within the class of naturally reductive left-invariant metrics on a compact simple Lie group G each metric is spectrally isolated. In particular, the bi-invariant metric on G is locally determined by its Laplace spectrum within this class. (Received February 15, 2011)

54 ► General topology

1070-54-78 **Deirdre M Scully*** (dmscul11@holycross.edu). *Overtwisted Contact Structures.*

A contact structure on a 3-dimensional manifold is a completely non-integrable plane field. In this project we study overtwisted contact structures, that is, which contain overtwisted disks. Contact structures without overtwisted disks are called tight. In particular we consider the complements of closed curves tangent to the contact structure in Dymara's overtwisted three-dimensional sphere. The goal of this project is to prove that the complement of certain closed curves tangent to Dymara's contact structure has no overtwisted disks.

Our method for proving the complement has no overtwisted disks is to decompose it by cutting along convex Seifert surfaces. A Seifert surface is a surface whose boundary is the closed curve in question. A Seifert surface is convex, if the contact structure is a product in a product neighborhood of the surface. Then we analyze the family of curves or foliation induced by the contact structure on the resulting boundary surfaces. Techniques that we have used in this process include simple perturbations and manipulation theorems from Eliashberg and Fraser. (Received January 26, 2011)

1070-54-323 **Jennifer Franko Vasquez***, The University of Scranton, Mathematics Department, Scranton, PA 18510. *Braid Group Representations with Finite Images.*

Any invertible matrix which satisfies the Yang Baxter Equation can be used to obtain representations of the braid group. During this talk we will consider some unitary solutions to the Yang Baxter Equation, the images of representations arising from these solutions, and the known link invariants these representations yield. (Received February 15, 2011)

55 ► Algebraic topology

1070-55-21 **Kristopher J. Williams*** (kristopher-williams@uiowa.edu), University of Iowa, Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52242. *Parallel connections of line arrangements and the associated Milnor Fiber.*

In 2005, a paper by Choudary, Dimca and Papadima explored higher dimensional analogs of affine nodal line arrangements. In particular, the authors were able to compute the homology of the associated Milnor fiber and showed that the monodromy action on the homology of the fiber was trivial except possibly in the top dimension. We extend their work to the more general class of parallel connections of central line arrangements and give an algorithm for computing the homology of the associated Milnor fiber F. In contrast to the work of Choudary, Dimca and Papadima, we give an example of a central arrangement in $\mathbb{C}^5$ such that the monodromy action on $H_3(F)$ and $H_4(F)$ is non-trivial. (Received December 10, 2010)

1070-55-58 **Thomas Tradler** (ttradler@citytech.cuny.edu), Department of Mathematics, College of Technology, City Univ. of New York, 300 Jay Street, Brooklyn, NY 11201, and **Ronald Umble*** (ron.umble@millersville.edu), Millersville University of Pennsylvania, Department of Mathematics, 208 Wickersham Hall, Millersville, PA 17551. *Tensor products of A_∞-algebras with homotopy inner products.*

Following Markl and Shnider, we construct an explicit combinatorial diagonal on the pairahedra, which are contractible polytopes controlling the combinatorial structure of an A_∞-algebra with homotopy inner products, and use it to define a categorically closed tensor product. A cyclic A_∞-algebra can be thought of as an A_∞-algebra with homotopy inner products whose higher inner products are trivial. However, the higher inner products on the tensor product of cyclic A_∞-algebras are not necessarily trivial. (Received February 04, 2011)

1070-55-61 **Michael P. Allocca*** (alloccam2@scranton.edu), Department of Mathematics, University of Scranton, Scranton, PA 18510. *A Concrete L_∞ Module and Its Induced L_∞ Structure.*

L_∞ modules are natural generalizations of Lie modules from a homotopy theoretical point of view. Furthermore, L_∞ modules induce canonical L_∞ algebra structures on the direct sum of their underlying graded vector spaces. We will briefly review these results and explore nontrivial concrete examples. (Received January 21, 2011)

1070-55-82 **Mahmoud Zeinalian*** (mzeinalian@liu.edu), **Thomas Tradler**, **Scott Wilson** and **Gregory Ginot**. *Equivariant holonomy of gerbes and higher Hochschild complexes.*

Consider the holonomy of a connection on a vector bundle E over a manifold M as a section of the pullback of the endomorphism bundle End(E) over the free loop space LM via the map that sends a loop to its basepoint. The covariant derivative of the this section is a 1-form on the loop space with values in this pullback bundle. A special feature of this 1-form naturally leads to completing the holonomy section to a mixed degree form with values in the above pullback bundle whose trace coincides with the Getzler-Jones-Petrack's description of the Bismut's equivariant Chern character. We will define higher Hochshcild complexes, give an axiomatic characterization of them as a certain (infinity, 1)-functor. We use higher Hochschild complexes to complete holonomy of a gerbe to a torus-equivariant differential form on the mapping space of the standard torus into M. This is report on the join works with G. Ginot, T. Tradler, S. Wilson. (Received January 28, 2011)

1070-55-105 **David E Hurtubise*** (Hurtubise@psu.edu), 16601. *Morse-Bott multicomplexes and cascades.*

Morse-Bott chain complexes are currently of interest in symplectic topology in relation to contact homology, Floer homology, and symplectic field theory. There are at least three different approaches to defining a Morse-Bott chain complex: 1) perturb the function to a Morse function, 2) use cascades, and 3) define a Morse-Bott multicomplex. In this talk I will give a brief outline of each approach and discuss how the first two approaches can lead to the same chain complex. (Received February 02, 2011)

1070-55-166 **Christine Escher*** (tine@math.orst.edu), Department of Mathematics, Oregon State University, Corvallis, OR 97330, and **Wolfgang Ziller**, University of Pennsylvania. *Topology of non-negatively curved manifolds.* Preliminary report.

In contrast to the positive curvature setting, there exist comparatively many examples with non-negative sectional curvature. Hence it is natural to ask whether, among the known examples, it is possible to topologically distinguish manifolds with non-negative curvature from those admitting positive curvature. In joint work with Wolfgang Ziller we address this question. In this talk, after briefly reviewing some of the history, I will describe the topology of two specific families of non-negatively curved manifolds in dimension seven and compare them to known examples of manifolds of positive curvature. (Received February 09, 2011)

1070-55-169 **Urtzi Buijs*** (ubuijs@ub.edu), Departament d'Àlgebra i Geometria, Universitat de Barcelona, Gran via de les Corts Catalanes 585, 08007, Barcelona, Spain. *L-infinity models of mapping spaces.*

The strength of rational homotopy theory relies on the fact that the rational homotopy category can be completely encoded by means of algebraic categories.

In particular, there are equivalences between the homotopy categories of rational nilpotent spaces of finite type and of commutative differential graded algebras on the one hand, and of rational 1-connected spaces and differential graded connected Lie algebras on the other hand.

The version up to homotopy of the latter algebraic structure corresponds to the the concept of L-infinity algebra, which was first introduced in the context of deformation theory and highly used since then in quite different geometrical settings.

In this talk we describe explicitly L-infinity algebras modeling components of the mapping space in terms of different models of the source and the target.

We show how these up to homotopy structures allow us to improve considerably some upper bounds of the Whitehead-length of mapping spaces. (Received February 09, 2011)

1070-55-239 **Alexandru I Suciu** (a.suciu@neu.edu), Department of Mathematics, Northeastern University, Boston, MA 02115, **Yaping Yang*** (yang.yap@husky.neu.edu), Department of Mathematics, Northeastern University, Boston, MA 02115, and **Gufang Zhao** (zhao.g@husky.neu.edu), Department of Mathematics, Northeastern University, Boston, MA 02115. *Homological finiteness of abelian covers.*

I will talk about a method for deciding when a regular abelian cover of a finite CW-complex has finite Betti numbers. To start with, I will describe a natural parameter space for all regular covers of a finite CW-complex X, with group of deck transformations a fixed abelian group A, which in the case of free abelian covers of rank r coincides with the Grassmanian of r-planes in $H^1(X, \mathbb{Q})$. Inside this parameter space, there is a subset $\Omega^i_A(X)$ consisting of all the covers with finite Betti numbers up to degree i.

We present here a method, which generalizes a theorem due to Dwyer and Fried, for computing these sets in terms of the jump loci for homology with coefficients in rank 1 local systems on X. For some nice spaces, e.g., quasi-Kähler manifolds, the generalized Dwyer-Fried invariants can be computed in terms of intersections of algebraic subtori in the character group. For many spaces of interest, the homological finiteness of abelian covers can be tested through the corresponding free abelian covers. Yet in general, abelian covers exhibit different homological finiteness properties than their free abelian counterparts. (Received February 13, 2011)

1070-55-290 **John McCleary** (mccleary@vassar.edu), **Matthew S Miller*** (mamiller@vassar.edu) and **Max Wakefield** (wakefiel@usna.edu). *A monoidal structure on the set of diagonal subspaces.*

In a classic paper from the 1960's Milgram used the bar construction of an H-space to calculate the homology of certain symmetric products. Our recent work, inspired by these classical methods, takes advantage of a monoidal structure on the set of diagonal subspaces in an effort to better understand the topology, particularly the cohomology, of certain classes of subspace arrangements. In this talk we will describe some of our constructions, results, and other information we hope to obtain by these methods. (Received February 14, 2011)

1070-55-332 **Amanda C Hager*** (amanda.hager@usma.edu), Department of Mathematical Sciences, 240 Thayer Hall, West Point, NY 10996. *Derivation Modules for Arrangement Bundles.*

If there is a modular element in the intersection lattice for a complexified real arrangement, then there exists a fiber bundle projection mapping in which the total space is the complement of the original arrangement and the base space and generic fiber are both arrangement complements. We explore a conjecture by Falk and Proudfoot that states that if the base and fiber arrangements are both free, then the total space arrangement is free. (Received February 15, 2011)

1070-55-337 **Somnath Basu*** (basu@math.sunysb.edu), Stony Brook University, NY. *Transversal string topology and invariants of manifolds.*

We consider the space of smooth paths (open strings) in $M \times M$ that start and end on the diagonal and only intersect the diagonal transversally, including the end points. At any of its intersection point such a string can be resolved by using the meridian lines connecting antipodal points of the normal sphere to the diagonal. Transversal open strings can also be naturally split at the intersection points giving rise to a differential graded coalgebra. This structure is interesting as it probes the homotopy type of the complement of the diagonal in $M \times M$ which is known not to be an invariant of the homotopy type of M. (Received February 15, 2011)

57 ► Manifolds and cell complexes

1070-57-3 **Walter D Neumann*** (neumann@math.columbia.edu). *What does a complex surface really look like?*

The metric geometry of a complex surface (2-dimensional variety over the complex numbers) turns out to be surprisingly complicated in the small. This talk will describe recent work by the speaker and L. Birbrair and A. Pichon, building partly also on work of A. Fernandez and D. O'Shea, which uses 3-manifold theory as a microscope to examine this geometry. (Received February 14, 2011)

1070-57-10 **Joseph Maher*** (joseph.maher@csi.cuny.edu), Department of Mathematics, 1S-215, 2800 Victory Boulevard, Staten Island, NY 11220. *Growth rates for stable commutator length.*

We'll give a brief introduction to stable commutator length, and describe some results on the growth rate of scl in various groups, including hyperbolic groups. This is joint work with Danny Calegari. (Received October 12, 2010)

1070-57-41 **P. Robert Kotiuga*** (prk@bu.edu), Boston University, ECE Dept., 8 Saint Mary's Street, Boston, MA 02215. *Whitney-form Finite Element Discretizations of Helicity Functionals: A Discrete Visual Understanding of Global Aspects.*

Whitney-form discretizations of Helicity functionals have been studied for over 20 years. We rephrase established results in terms of a complex with some additional structure. A nice duality between 1-simplices and their "links" is at the center of the identification of the exterior derivative's domain mod its kernel, with its range mod cokernel. Consequently it:

1) Relates to the preprints of Sullivan and Wilson (below).

2) Provides an easily understandable connection to "logically rectangular meshes". It also gives a very geometric way of thinking about Reidemeister torsion as an obstruction to having "logically rectangular meshes".

3) Invites a discussion of topologies on the space of cochains which preserve continuum structure.

4) Naturally extends to the exterior derivative on 2k-1-forms in a 4k-1-dimensional space, with a combinatorial interpretation.

P. R. Kotiuga, "Theoretical Limitations of Discrete Exterior Calculus in the Context of Computational Electromagnetics". IEEE Trans. Mag, 44(6) 1162-1165

S. O. Wilson, "Differential forms, fluids, and finite models" submitted to Proc. of AMS, Jan. 2010.

D. Sullivan, "Algebra, Topology and Algebraic Topology of 3D Ideal Fluids" ArXiv: 1010.2721v1 [math.AT]
(Received December 21, 2010)

1070-57-68 **Patrick M Gilmer*** (gilmer@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, and **Gregor Masbaum**. *Irreducibility properties of modular representations of mapping class groups arising in TQFT.*

We find decomposition series of length at most two for the modular representations of the mapping class groups of a one-holed surfaces induced by integral TQFT. (Received January 23, 2011)

1070-57-70 **John Berge** and **Brandy Guntel*** (bguntel@math.utexas.edu), 1 University Station C1200, Austin, TX 78712, and **Sungmo Kang**. *Classifying primitive/Seifert knots.* Preliminary report.

Among knots that lie on the genus 2 Heegaard surface for S^3, two classes of knots, the primitive/primitive and primitive/Seifert knots, are of particular interest because they admit lens space surgeries and Seifert fibered surgeries, respectively. The primitive/primitive knots were introduced by Berge; the primitive/Seifert knots, introduced by Dean, are a natural generalization of the primitive/primitive knots. In Berge's work, he classified the primitive/primitive knots. In this talk, I will discuss work, joint with John Berge and Sungmo Kang, to classify the primitive/Seifert knots. (Received January 24, 2011)

1070-57-73 **Lee Rudolph*** (lrudolph@black.clarku.edu), Department of Mathematics & Computer Science, Clark University, 950 Main Street, Worcester, MA 01610. *On the minimal degree of a transverse* $\mathbf{C}$*-link, with an application to topological slice genus of classical knots.* Preliminary report.

A *transverse* $\mathbf{C}$*-link in dimension* $2n+1$ is a pair (K, S^{2n+1}) isotopic to some (M, Σ), where $M = V \cap \Sigma$ for some complex hypersurface $V \subset \mathbf{C}^{n+1}$ having at most isolated singularities and some strictly pseudoconvex $(2n+1)$-sphere $\Sigma \subset \mathbf{C}^{n+1}$. Boileau & Orevkov showed that transverse $\mathbf{C}$-links in dimension 3 coincide with the author's "quasipositive links", about which various things have been proved in the past 30 years. On the other hand little is known about transverse $\mathbf{C}$-links in dimension $2n+1 > 3$, not even just which 3-manifolds can be realized as K.

Let $\deg_{\mathbf{C}}(K, S^{2n+1})$ be the minimum degree of such a hypersurface V as above; let $\deg_{\mathbf{C}}(K)$ be the minumum $\deg_{\mathbf{C}}(K', S^{2n+1})$ over all transverse $\mathbf{C}$-links with K' diffeomorphic to K (preserving orientation). These seemingly banal invariants actually have some interest. (1) Boileau and the author (unpublished) found many links M^3 of surface singularities in $\mathbf{C}^3$ with $\deg_{\mathbf{C}} M < \deg(V)$ for any V having that singularity. (2) $\deg_{\mathbf{C}}(K, S^3)$ bounds can sometimes determine the *topological*(ly locally flat) slice genus of a knot (K, S^3)—e.g., $g_t(8_{18}) = 3 = g_t(9_{40})$. (Received January 27, 2011)

1070-57-80 **Jesse Johnson*** (jjohnson@math.okstate.edu), 2131 Sunset Dr., Stillwater, OK 74074.
Common stabilizations of Heegaard splittings.

A Heegaard splitting is a decomposition of a 3-manifold into two simple pieces called handlebodies. It has long been known that any two Heegaard splittings of the same 3-manifold are related by repeating a construction called stabilization. However, the early proofs of this fact gave no suggestion of how many stabilizations might be needed to turn one Heegaard splitting into another. I will describe a sharp upper bound on the necessary number of stabilizations. (Received January 27, 2011)

1070-57-118 **Shawn Rafalski*** (srafalski@fairfield.edu), Fairfield University, Fairfield, CT. *Small hyperbolic polyhedra.*

The existence (or non-existence) of an embedded essential surface provides important information about a 3–manifold. We will discuss an orbifold analogue of this notion, by analyzing the hyperbolic polyhedral 3–orbifolds that contain no embedded essential 2–suborbifolds (up to a canonical decomposition). We will also address the related question of the classification of triangle subgroups of 3–dimensional hyperbolic polyhedral reflection groups. (Received February 04, 2011)

1070-57-121 **Neil R Hoffman*** (nhoffman@math.utexas.edu). *Exceptional Surgeries and Hidden Symmetries.* Preliminary report.

In 2006, Reid and Walsh conjectured that there are at most 3 hyperbolic knot complements in a commensurablity class. Recently, Boileau, Boyer, Cebanu, and Walsh have shown that the conjecture holds in the case of no hidden symmetries. Their results shows that commensurable knot complements occur in conjunction with exceptional fillings on a particular hyperbolic orbifold. In this talk, I will show that the figure 8 knot complement is the only knot complement that can admit a non-trivial exceptional surgery and hidden symmetries. (Received February 04, 2011)

1070-57-139 **Eric Harper*** (harper@cirget.ca), Universite du Quebec a Montreal, Case postale 8888, Succursale centre-ville, Montreal, Quebec H2X 3Y7, Canada, and **Nikolai Saveliev**.
Casson-Lin type invariants for links.

In 1992, Xiao–Song Lin constructed an invariant $h(K)$ of knots $K \subset S^3$ that is a signed count of conjugacy classes of irreducible trace–free $SU(2)$ representations of $\pi_1(S^3 \backslash K)$. Lin shows $h(K)$ is one half the knot signature of K. Using methods similar to Lin's, we construct an invariant $h(L)$ of two–component links $L \subset S^3$. Our invariant is a signed count of conjugacy classes of *projective* $SU(2)$ representations of $\pi_1(S^3 \backslash L)$ with a fixed 2–cocycle and corresponding non-trivial w_2. We show that $h(L)$ is, up to a sign, the linking number.

In addition, we construct an instanton Floer homology for any link of two components in an integral homology sphere. We show that its Euler characteristic is the linking number between the components of the link and that the Floer homology is nontrivial for nonsplit links in S^3. (Received February 07, 2011)

1070-57-146 **Eric B. Chesebro*** (eric.chesebro@mso.umt.edu). *Closed surfaces and the character variety.* Preliminary report.

In the eighties, Culler and Shalen developed a procedure for using the $\mathrm{SL}(2,\mathbb{C})$-character variety for a 3-manifold to construct essential surfaces in the manifold. Since then, their techniques have been carefully studied and are critical in the proofs of several famous theorems. Most of the invesigation of the Culler-Shalen machinery has focused on the case when the associated essential surface has non-empty boundary. Here we will review the basics of their theory and give a new characterization of when associated surfaces are closed. (Received February 07, 2011)

1070-57-162 **Daniel D Moskovich***, Department of Mathematics, 40 St. George Street, Bahen Centre, Toronto, Ontario M5S 2E4, Canada. *First steps in coloured knot theory.*

A 3-manifold is presented as a branched covering space of S^3 over a coloured knot. I will discuss invariants of coloured knots. The theory of coloured knots parallels ordinary knot theory to some extent- there are coloured analogues to Seifert matrices, crossing changes, knot polynomials, and a lot more. We will take some first steps in coloured knot theory with a Dehn surgery theoretic approach. (Received February 08, 2011)

1070-57-189 **Keiko Kawamuro*** (kawamuro@iowa.uiowa.edu), 14 McLean Hall, Iowa City, IA 52240.
The self linking number and open book decomposition.

I investigate null-homologous transverse knots in contact 3-manifolds through an invariant called the self linking number. By using Giroux, Bennequin and Pevelescu's works, we can view them as null-homologous braids in open book decompositions. I will present a formula of the self linking number. The main tool is the characteristic foliation on a Seifert surface. (Received February 10, 2011)

1070-57-241 **Genevieve S Walsh*** (genevieve.walsh@gmail.com). *Some 3-manifolds with large fundamental group.* Preliminary report.

A group is large if it virtually surjects a free group of rank 2. We say a manifold or orbifold is large if it has a large fundamental group. We present a simple construction to produce lots of examples of large hyperbolic 3-manifolds. This is joint work with Thomas Koberda. (Received February 13, 2011)

1070-57-242 **Genevieve S. Walsh*** (genevieve.walsh@gmail.com). *Some cubed hyperbolic 2- and 3-manifolds.*

Given a Coxeter group with defining graph a triangulation of an (n-1)-sphere, we produce an n-manifold with an underlying cubed structure, which naturally sits in a higher-dimensional Euclidean space. We explore the ramifications when n is 2 or 3. Here, given simple conditions on the defining graph, the manifold is hyperbolic. This is joint work with Sam Kim. (Received February 14, 2011)

1070-57-255 **Tao Li*** (taoli@bc.edu), Department of Mathematics, Boston College, Chestnut Hill, MA 02467. *The Rank versus Genus Conjecture.*

We construct a counterexample to the Rank versus Genus Conjecture (also known as the Rank Conjecture), i.e., a closed orientable hyperbolic 3-manifold with rank of its fundamental group smaller than its Heegaard genus. We also construct toroidal such examples that contain hyperbolic JSJ pieces. (Received February 14, 2011)

1070-57-264 **Christopher K. Atkinson*** (ckatkin@temple.edu), Department of Mathematics, Wachman Hall, 1805 N. Broad St., Philadelphia, PA 19106. *Geometry and topology of polyhedral* 3*–orbifolds.*

We will describe the geometric decomposition of polyhedral 3–orbifolds. We will show how this decomposition can be detected algorithmically and how it can be applied to yield lower volume bounds for hyperbolic polyhedral orbifolds. (Received February 14, 2011)

1070-57-267 **Daryl Cooper** (cooper@math.ucsb.edu), PA, **David Futer*** (dfuter@temple.edu), Philadelphia, PA 19122, and **Jessica S Purcell** (jpurcell@math.byu.edu). *The geometry of unknotting tunnels.*

Given a 3-manifold M, with boundary a union of tori, an unknotting tunnel for M is an arc τ from the boundary back to the boundary, such that the complement of τ in M is a genus-2 handlebody. Fifteen years ago, Colin Adams asked a series of questions about how the topological data of an unknotting tunnel fits into the hyperbolic structure on M. For example: is τ isotopic to a geodesic? Can it be arbitrarily long, relative to a maximal cusp neighborhood? Does τ appear as an edge in the canonical polyhedral decomposition?

Although the most general versions of these questions are still open today, I will describe fairly complete answers in the case where M is created by a "generic" Dehn filling. As an application, there is an explicit family of knots in S^3 whose tunnels are arbitrarily long. This is joint work with Daryl Cooper and Jessica Purcell. (Received February 14, 2011)

1070-57-268 **David Futer*** (dfuter@temple.edu), Mathematics Department, Temple University, Philadelphia, PA 19122, and **Efstratia Kalfagianni** (kalfagia@math.msu.edu) and **Jessica S Purcell** (jpurcell@math.byu.edu), 19147. *Slopes and colored Jones polynomials of adequate knots.*

Garoufalidis conjectured a relation between the boundary slopes of a knot and its colored Jones polynomials. According to the conjecture, certain boundary slopes are detected by the sequence of degrees of the colored Jones polynomials. We prove this conjecture for *adequate* knots, a class that vastly generalizes that of alternating knots. (Received February 14, 2011)

1070-57-273 **Walter D Neumann*** (neumann@math.columbia.edu). *3-manifolds and number theory.*

This talk, by request, will be an overview of some of the connections between three-dimensionalal topology and number theory. (Received February 14, 2011)

1070-57-278 **Uwe Kaiser*** (kaiser@math.boisestate.edu), Department of Mathematics, Boise State University, Boise, ID 83725. *On the categorification of skein modules and algebras.* Preliminary report.

Asaeda, Przytycki and Sikora categorified skein modules of surfaces in the strong sense of categorifying the polynomial invariants defined from a module basis of the dual module in the sense of Khovanov homology. A *weak* categorification of the skein module of a 3-manifold could be an abelian category with Grothendieck group the skein module of the 3-manifold. We discuss some few ideas towards such a construction. It leads to a category with morphisms defined from band-operations relating essentially the links of skein triples. The geometric skein

equivalence relation on links should be essential in the construction of the necessary abelian structure of such a category. (Received February 14, 2011)

1070-57-291 **Kathleen Petersen*** (petersen@math.fsu.edu). *A-polynomials of a family of two-bridge knots.*

The A-polynomial is a two variable polynomial associated to a knot complement which encodes a lot of topological data about the knot complement. For a certain family of two-bridge knots containing the twist knots, we compute the A-polynomial from the SL(2,C) character variety using field norms. (Received February 15, 2011)

1070-57-292 **Kenneth Baker** and **Kathleen Petersen*** (petersen@math.fsu.edu). *Character Varieties of a Family of Once-Punctured Torus Bundles.*

The SL(2,C) character variety of a finite volume hyperbolic 3-manifold with one cusp is a complex algebraic set whose canonical component is a complex curve. By computing explicit equations for the SL(2,C) character varieties of a family of manifolds, we will compare geometric invariants of this curve with topological invariants of the manifold. (Received February 14, 2011)

1070-57-302 **Jesse Johnson** and **Maggy Tomova*** (maggy-tomova@uiowa.edu), 14 MacLean Hall, Iowa City, IA 52242. *Flipping bridge surfaces and bounds on the stable bridge number.*

We show that if K is a knot in S^3 and Σ is a bridge sphere for K with high distance and $2n$ punctures, the number of perturbations of K required to interchange the two balls bounded by Σ via an isotopy is n. We also construct a knot with two different bridge spheres with $2n$ and $2n-1$ bridges respectively for which any common perturbation has at least $3n-1$ bridges. We generalize both of these results to bridge surfaces for knots in any 3-manifold. (Received February 15, 2011)

1070-57-309 **Eric Chesebro** and **Jason DeBlois*** (jdeblois@math.stanford.edu). *Hidden symmetries of links via mutations with hidden extension.*

Given a 3-manifold M with non-empty boundary, say that an automorphism ϕ of a surface $S \subset \partial M$ has a *hidden extension* if there is a finite-degree cover $N \to M$ and a lift of ϕ to the preimage of S that extends over N. I will describe an example where a mutation with hidden extension gives rise to a family of hyperbolic link complements in S^3 that have hidden symmetries. (Received February 15, 2011)

1070-57-310 **Charles D. Frohman** and **Joanna Kania-Bartoszynska***, jkaniaba@nsf.gov. *Torsion, A-polynomial and quantum invariants of knots.*

Given a knot in the 3-sphere with a sufficiently regular character variety, we describe a chain complex (following Dubois) whose torsion yields a knot invariant. This invariant is used to define a seminorm on the Kauffman bracket skein algebra of the boundary torus for the knot complement. The radical of this seminorm is the ideal of functions that vanish on the image of the irreducible representations of the knot complement in the character variety of the torus. We derive a global formula for the seminorm that looks like the Witten-Reshetikhin-Turaev invariant of the skein in the double of the knot complement. This leads us to a conjectural characterization of the A-polynomial of knots with sufficiently regular character varieties in terms of quantum invariants. The conjecture is supported by the fact that the Dubois' torsion of a knot is a geometrically motivated evaluation of the square root of the Reidemeister torsion of the double of the knot complement. (Received February 15, 2011)

1070-57-317 **Ryan C Blair*** (ryblair@math.upenn.edu) and **Maggy Tomova**. *Width is Not Additive.*

We examine the behavior of Gabai's notion of width of a knot under the operation of connected sum. We develop the construction suggested by Scharlemann and Thompson to obtain an infinite family of pairs of knots K_1 and K_2 so that $w(K_1 \sharp K_2) = max\{w(K_1), w(K_2)\}$. This is the first known example of a pair of knots such that $w(K_1 \sharp K_2) < w(K_1) + w(K_2)$. (Received February 15, 2011)

1070-57-320 **Robert Meyerhoff***, Dept. of Math., Boston College, Chestnut Hill, MA 02467. *In Search of the First Infinite Hyperbolic Volume Stem.* Preliminary report.

The figure-eight knot complement and its sibling are the one-cusped hyperbolic 3-manifolds of minimum volume, and this volume is the limit (from below) of a sequence of volumes of closed hyperbolic 3-manifolds. It would be thrilling to identify every one of the hyperbolic 3-manifolds with volumes in this sequence. However, it seems as if we are rather far away from solving this problem. But the following similar problem might be considerably more tractable: Identify the entire collection of one-cusped hyperbolic 3-manifolds whose volumes form the sequence of (one-cusped) volumes approaching the 2-cusped minimum volume. In this talk we discuss some approaches to this problem. This is joint work with D. Gabai and N. Thurston. (Received February 15, 2011)

1070-57-328 **Melissa Macasieb*** (macasieb@math.umd.edu) and **Kathleen Petersen** (petersen@math.fsu.edu). *Character varieties and symmetries of 2-bridge knots.* Preliminary report.

We investigate the relationship between the symmetry group of a 2-bridge knot group and the number of irreducible components of its $SL_2(C)$-character variety. (Received February 15, 2011)

1070-57-331 **Ilesanmi Adeboye*** (adeboye@math.ucsb.edu). *Volumes of Hyperbolic Orbifolds.*

In this talk, a result due to H. C. Wang, and some comparison geometry, is used to construct an explicit lower bound for the volume of a hyperbolic orbifold dependent only on dimension. The techniques are then generalized to all rank one symmetric spaces of noncompact type. This is joint work with Guofang Wei. (Received February 15, 2011)

1070-57-333 **Julien Roger*** (juroger@math.rutgers.edu), Department of Mathematics, Rutgers University, 110 Frelinghuysen Rd., Piscataway, NJ 08854-8019. *Quantum Teichmüller theory and conformal field theory.*

The aim of this talk is to describe the construction of the quantum Teichmüller space, emphasizing its connection with hyperbolic geometry and the Weil-Petersson geometry of Teichmüller space, and then to analyze its relationship with conformal field theory. One of the goals of this work is the construction of a family of representations of the mapping class groups, also known as a modular functor. (Received February 15, 2011)

1070-57-334 **Constance Leidy*** (cleidy@wesleyan.edu), 265 Church Street, Middletown, CT 06457. *Calculating non-commutative topological invariants of line arrangements.* Preliminary report.

We will define some topological invariants of line arrangements that result from studying the non-commutative structure of certain modules associated to the arrangement. These were defined by the speaker and L. Maxim. Unfortunately, these invariants are difficult to compute. We will discuss some progress on finding algorithms to compute them. (Received February 15, 2011)

1070-57-340 **Michael John Williams*** (mwilliam@ucr.edu), Department of Mathematics, 202 Surge Building, University of California, Riverside, CA 92521, and **Abigail Thompson** (thompson@math.ucdavis.edu), Department of Mathematics, One Shields Ave, University of California, Davis, CA 95616. *On nonhyperbolic handle number one links.* Preliminary report.

The handle number of a link in the three sphere is the least number of disjoint proper arcs needed to be attached to the link so that resulting (possibly disconnected) graph is unknotted. In particular, the exteriors of handle number one links admit genus 2 Heegaard splittings. In this talk, some results on nonhyperbolic handle number links will be presented. (Received February 16, 2011)

58 ► Global analysis, analysis on manifolds

1070-58-95 **Emily B. Proctor*** (eproctor@middlebury.edu). *Orbifold homeomorphism finiteness based on geometric constraints.*

I will present a new result that any collection of n-dimensional orbifolds with sectional curvature and volume uniformly bounded below, diameter bounded above, and with only isolated singular points contains orbifolds of only finitely many orbifold category homeomorphism types. This is a generalization to the orbifold category of a similar result for manifolds proven by Grove, Petersen, and Wu. An immediate corollary is that any Laplace isospectral collection of orbifolds with sectional curvature uniformly bounded below and having only isolated singular points also contains only finitely many orbifold homeomorphism types. (Received February 01, 2011)

1070-58-188 **Emily B. Proctor*** (eproctor@middlebury.edu). *Infranil-orbifolds and isospectral sectors.* Preliminary report.

For a nilpotent Lie group G, the action of $\mathrm{Aut}(G) \ltimes G$ on G is not necessarily free. By letting a lattice $\Pi \subset \mathrm{Aut}(G) \ltimes G$ act on G, we can therefore obtain an orbifold as the quotient $\Pi\backslash G$. We call such an orbifold an infranil-orbifold. In 2010, Stanhope and I gave an example of a Laplace isospectral deformation of metrics on an infranil-orbifold using a generalization of Sunada's theorem. In this talk, I will explain the notion of Γ-sectors of an orbifold, and indicate how the example above may prove useful in the study of the Γ-Laplace spectrum of an orbifold. (Received February 10, 2011)

1070-58-258 **Ruth Gornet*** (rgornet@uta.edu) and **Ken Richardson** (k.richardson@tcu.edu). *Dirac Operators and Eta Invariants on nilmanifolds.* Preliminary report.

We discuss dirac operators and eta invariants on nilmanifolds. (Received February 14, 2011)

1070-58-287 **Carolyn S. Gordon*** (csgordon@dartmouth.edu) and **Dorothee Schueth** (schueth@math.hu-berlin.de). *Quantum equivalent magnetic fields on flat tori that are not classically equivalent.* Preliminary report.

Given a translation invariant symplectic structure on a flat torus, one associates a Hermitian line bundle and a Laplace operator acting on sections of the line bundle and its tensor powers. We construct different symplectic structures for which the Laplacians on the associated line bundles and their non-trivial tensor powers are isospectral. The primary tool in the construction is the Heisenberg structure on the unit circle bundles.

In the context of geometric quantization, we interpret these examples as quantum equivalent magnetic fields that are not classically equivalent. (Received February 14, 2011)

60 ► Probability theory and stochastic processes

1070-60-46 **Sunil Chhita*** (schhita@math.brown.edu), Mathematics Department, Box 1917, Brown University, Providence, RI 02906. *Particle Systems arising from an Anti-ferromagnetic Ising Model.*

We present a low temperature anisotropic anti-ferromagnetic 2D Ising model through the guise of a certain dimer model. This model has a bijection with a one-dimensional particle system equipped with creations and annihilations. We give the exact phase diagram, which determines two significant values - the independent and critical values. We also present some results for the behavior of the model in the scaling window. (Received January 03, 2011)

1070-60-48 **David Jerison**, **Lionel Levine*** (levine@math.mit.edu) and **Scott Sheffield**. *Logarithmic fluctuations from circularity.*

Start with n particles at the origin in the square grid $\mathbb{Z}^2$, and let each particle in turn perform simple random walk until reaching an unoccupied site. Lawler, Bramson and Griffeath proved that with high probability the resulting random set of n occupied sites is close to a disk. We show that its fluctuations from circularity are, with high probability, at most logarithmic in the radius of the disk, answering a question posed by Lawler in 1995. These logarithmic fluctuations were predicted numerically by chemical physicists in the 1980's. We also show that certain space-time averages of the fluctuations from circularity converge in law to a variant of the Gaussian free field. (Received January 05, 2011)

1070-60-50 **Wlodek Bryc*** (brycw@math.uc.edu) and **Gerard Letac**. *Meixner matrix ensembles.*

In this talk I will discuss random matrices that are matricial analogs of the well known binomial, Poisson, and negative binomial random variables. The defining property is that the conditional variance of X given the sum $S = X + X'$ of two independent copies of X is a quadratic polynomial in S; this property describes the family of six univariate laws on $\mathbb{R}$ that will be described in the talk, and we are interested in their matrix analogs. (Received January 10, 2011)

1070-60-65 **Paul Bourgade*** (bourgade@math.harvard.edu), Science Center, One Oxford Street, Cambridge, MA 02138. *Extreme spacings for eigenvalues of random matrices.*

This is a joint work with Gerard Ben Arous about the extreme gaps between eigenvalues of random matrices. We give the joint limiting law of the smallest gaps for Haar-distributed unitary matrices and matrices from the Gaussian Unitary Ensemble. In particular, the smallest gaps, when rescaled by $n^{-4/3}$, are Poissonian with an explicit limiting density. Concerning the largest gaps, normalized by $\sqrt{\log n}/n$, they converge in L^p to a constant for all positive p. We compare these results with the extreme gaps between zeros of the Riemann zeta function (Received January 22, 2011)

1070-60-67 **Andrew Ledoan*** (ledoan@bc.edu), Boston College, Carney Hall, Room 228, 140 Commonwealth Avenue, Chestnut Hill, MA 02467-3806, **Marco Merkli** (merkli@mun.ca), Memorial University of Newfoundland, St. John's, NL, A1C 5S7, Canada, and **Shannon Starr** (sstarr@math.rochester.edu), University of Rochester, Hylan Building, Room 1017, Rochester, NY 14627-0138. *Remark on a universality property of Gaussian analytic functions.*

We consider random analytic functions defined on the unit disk of the complex plane as power series such that the coefficients are independent and identically distributed, complex-valued random variables with mean zero and unit variance. Y. Peres and B. Virág have successfully shown that for the case of complex Gaussian coefficients, the zero set forms a determinantal point process with the Bergman kernel. Here we show that for general choices of random coefficients, the zero set is asymptotically given by the same distribution near the boundary of the disk. (Received January 23, 2011)

1070-60-123 **Alex Bloemendal*** (alexb@math.toronto.edu), Department of Mathematics, University of Toronto, Room 6290, 40 St. George Street, Toronto, ON M5S 2E4, Canada. *Finite rank perturbations of large random matrices.*

Finite (or fixed) rank perturbations of large random matrices arise in a number of applications. The main phenomenon is a phase transition in the largest eigenvalues as a function of the perturbation. I will describe joint work with Bálint Virág in which we introduce a new way to study these models. The starting point is a reduction to a natural band form; under the soft edge scaling, it converges to a souped-up version of the known continuum random Schrödinger operator on the half-line. We describe the near-critical fluctuations in several ways, solving a known open problem in the real case. One characterization—a simple linear PDE—also yields a new route to the Painlevé structure in the celebrated Tracy-Widom laws. (Received February 05, 2011)

1070-60-160 **Richard W Kenyon*** (rkenyon@math.brown.edu). *Cycle-rooted spanning forests.*

The cycle-rooted spanning forest (CRSF) on a graph is a natural generalization of a spanning tree. It is a subset of the edges of a graph in which each component has as many vertices as edges. We study natural determinantal probability measures on CRSFs. We show that in appropriate scaling limits on the square grid, the cycle structure is conformally invariant. (Received February 08, 2011)

1070-60-167 **Murat Kologlu*** (Murat.Kologlu@williams.edu), **Steven J Miller** (Steven.J.Miller@williams.edu) and **Gene Kopp**. *Distributions of Eigenvalues of Real Symmetric m-Circulant Matrices.*

Random matrix ensembles model many phenomena, from nuclear energy levels to L-function zeros. The idea is to generate $N \times N$ matrices from some nice distribution and look at their spectra. As $N \to \infty$, the behavior of the eigenvalues of a typical matrix is close to the ensemble average. However, few ensembles are well-understood, and current theorems rarely illustrate transitions between ensembles. We study real symmetric m-circulant matrices with entries i.i.d.r.v. An m-circulant matrix has toroidal diagonals periodic of period m. We view m as a dial we can turn from the highly structured real symmetric circulant matrices to the ensemble of all real symmetric matrices. The limiting eigenvalue densities p_m show a visually stunning convergence from a Gaussian to the semicircle as $m \to \infty$. We prove this convergence. We also prove that p_m is the product of a Gaussian and a certain even polynomial of degree $2m - 2$. The proof is by derivation of the moments from the eigenvalue trace formula. The key step is converting the central combinatorial problem in the calculation to an equivalent problem about Euler characteristic and algebraic topology. This is joint work with Gene Kopp and Steven J. Miller. (Received February 09, 2011)

1070-60-170 **Adrien Kassel*** (adrien.kassel@ens.fr), 45 rue d'Ulm, 75005 Paris, France. *Geometrical properties of certain determinantal processes.*

We introduce qdeterminantal processes, which are a generalization of determinantal and Pfaffian processes, where the usually complex-valued kernel takes quaternionic values. Our purpose is to give a better description of certain random point processes living on embedded graphs. In this light, we present results on two models: the CRSF (a geometrical generalization of the uniform spanning tree recently introduced by Richard Kenyon), and dimers on bipartite graphs. We also comment on applications to other Pfaffian processes and address the question of sampling. (Received February 09, 2011)

1070-60-209 **Mihai Stoiciu*** (mstoiciu@williams.edu), Department of Mathematics and Statistics, Bronfman Science Center, Williams College, Williamstown, MA 01267. *Random Matrices with Poisson Eigenvalue Statistics.* Preliminary report.

We describe several classes of random matrices, both Hermitian and unitary, which exhibit local (microscopic) Poisson eigenvalue statistics. We describe the general strategy for proving these results and discuss connections between classes of random matrices with this property. We also present numerical evidence supporting the conjecture that the Poisson eigenvalue statistics holds for random non-Hermitian Anderson models (Hatano-Nelson matrices). (Received February 12, 2011)

62 ► Statistics

1070-62-338 **Salil Kumar Das*** (DasSK@pgcc.edu), 1100 Mondrian Terrace, Silver Spring, MD 20904, and **George Perkins**. *Undergraduate Research based on R Through Excel.* Preliminary report.

The purpose of this talk is to present and demonstrate an efficient data analysis tool that combines the power of R, a language that has become a standard among statisticians, all over the world, for the development of statistical software, and Excel that provides a familiar interface with user friendly control mechanisms. By placing any R function inside the Excel spreadsheet automatic recalculation mode, the full power of R, one of the best programs for statistical analysis and graphical display of data, has been placed into a familiar user environment. In this presentation some elementary commands in R to do basic statistics at the undergraduate level will be presented. It will be shown that the R graphics which demonstrate the concepts of hypothesis testing, confidence intervals, regression analysis, ANOVA and several other important statistical calculations, which are the hallmark of most of the undergraduate research in many branches of statistics, mathematics, sciences and social sciences, can be controlled through Excel spreadsheets. The efficacy of R as compared to other point-and-click GUI based statistical software packages will be demonstrated. (Received February 15, 2011)

65 ► Numerical analysis

1070-65-83 **Jean-Christophe Nave*** (jcnave@math.mcgill.ca), 805 Sherbrooke W., Montreal, QC H3A 2K6, Canada, and **Benjamin Seibold** and **Ruben Rosales**. *High-order, optimally-local schemes for the advection equation.*

I will present a new set of numerical schemes to solve the linear advection equation. These new schemes are semi-Lagrangian and use a Hermite interpolation projection. This combination allows for several interesting properties such as optimal-locality of stencils, high-order, and sub-grid accuracy. I will present third and fifth order versions of these schemes and show applications to interface tracking problems. (Received January 28, 2011)

70 ► Mechanics of particles and systems

1070-70-129 **Eduardo S. G. Leandro***, 215 Benesfort Cr, Kitchener, Ontario N2N 3B4, Canada. *Harmonic Analysis on Finite Groups and the Problem of Linear Stability of Symmetric Relative Equilibria.*

In his celebrated Adams Prize winning memoir from 1856, J. C. Maxwell used harmonic analysis to factor the so-called secular (or stability) polynomial associated to the centered regular n-gon relative equilibrium in the Newtonian n-body problem. This factorization allowed Maxwell to study the linear stability of the centered n-gon. Later on, Poincare', Palmore, Meyer&Schmidt, Moeckel, Roberts and others have applied similar arguments in their respective linear stability and bifurcation analysis of the (centered) n-gon. In this talk, I discuss a group theoretical framework which leads to a generalization of Maxwell's factorization to other classes of symmetric relative equilibria. (Received February 06, 2011)

1070-70-168 **Josep M. Cors*** (cors@epsem.upc.edu). *Central Configurations of the planar 1+3 body problem.*

We study configurations with one massive central mass, M, and several infinitesimal co–orbital satellites (in our case, 3 satellites) describing the same circular orbit around M. A configuration that allows relative equilibria (in

a rotation frame the satellites remain fixed) and homographic motions (the configuration of the satellites change it size, but keep the shape) is called central configuration.

We obtain two different classes of central configurations depending on the mutual distances between the infinitesimal masses. Both classes exhibit symmetric and non–symmetric configurations. In the case when two infinitesimal masses are equal we provide evidence that the number of central configurations varies from five to seven. (Received February 09, 2011)

1070-70-235 **Cristina Stoica*** (cstoica@wlu.ca). *On relative equilibria of N-point-mass rotationally invariant systems.*

About 20 years ago, J.E. Marsden and co-workers established a methodology for deciding the stability of a relative equilibrium of a Hamiltonian system. Since then, this method, known as the reduced energy-momentum (REM), was applied to various problems such as the double spherical pendulum, pseudo-rigid bodies (liquid drops) and vortex systems.

This talk presents an application of REM to planar rotationally invariant relative equilibria of three-point-mass systems. Two examples are discussed in detail: equilateral relative equilibria for the classical three-body problem, and isosceles triatomic molecules. We also mention further applications to more general N-point-mass systems, as well as simplifications induced by additional discrete symmetries of the relative equilibrium configuration. (Received February 13, 2011)

1070-70-266 **Samuel R Kaplan*** (skaplan@unca.edu), One University Heights, CPO #2350, Asheville, NC 28804. *Eccentricity and co-orbital dynamics.* Preliminary report.

A planar three-body system is co-orbital when there is a dominant central mass and two small masses orbiting with nearly equal radii. There are two well-explored sets of parameters where the small bodies either pass each other, acting as independent Kepler problems or the two bodies switch orbits, called a horseshoe orbit. For parameters between these two cases, there is the possibility of near-collision behavior. Presented is a numerical survey of these in-between parameters and the ensuing changes in eccentricity. (Received February 14, 2011)

1070-70-276 **Elizabeth A Zollinger*** (zollingerea@hiram.edu). *Minimizing orbits in the Newtonian 3-body problem.*

For the equal mass 3-body problem we use variational techniques to prove the existence of a family of orbits. As a one parameter family, the orbits foliate the shape sphere without passing through collision. One extreme looks like the classic comet, with the "comet" relatively far away from the other two. The other extreme comes close to the Schubart orbit, where one body goes back and forth between collisions with the other two. We will be especially interested in looking at how this family relates to the orbits presented numerically by Hénon and the collision orbit of Schubart. (Received February 14, 2011)

1070-70-295 **Gregory R. Buck*** (gbuck@anselm.edu). *An Equation of Motion for Filaments.*

Filaments are ubiquitous – they appear on every scale studied by science. We present here an equation for the self induced motion for an attracting or repelling filament or filamentary distribution of matter. Applications include celestial distributions such as spiral arms of galaxies, as well as charged strings, and perhaps biofilaments such as DNA. (Received February 14, 2011)

1070-70-321 **Gareth E. Roberts*** (groberts@radius.holycross.edu) and **Josep M. Cors**. *Cyclic Central Configurations in the Four-Body Problem.*

We classify the set of central configurations lying on a common circle in the Newtonian four-body problem. Such a configuration will be referred to as a cyclic central configuration. Using mutual distances as coordinates, we show that the set of cyclic central configurations with positive masses is a two-dimensional surface, a graph over two of the exterior side-lengths. Two symmetric families, the kite and isosceles trapezoid, are investigated extensively. We prove a specific ordering of the masses is required and find explicit bounds on the mutual distances. In contrast to the general four-body case, we show that if any two masses of a cyclic central configuration are equal, then the configuration has a line of symmetry. In addition to utilizing many analytic arguments, our techniques also invoke classical geometry (e.g., the Cayley-Menger determinant and Ptolemy's Theorem) as well as modern computational algebra (e.g., Groebner bases and Sturm's Theorem.) (Received February 15, 2011)

74 ► Mechanics of deformable solids

1070-74-26 **Mark D Behn*** (mbehn@whoi.edu), Woods Hole Oceanographic Institution, Department of Geology and Geophysics, 360 Woods Hole Road – Mail Stop 22, Woods Hole, MA 02543, and **Michael J Krawczynski**, **Sarah B Das** and **Ian Joughin**. *The role of supra-glacial lakes in supplying meltwater to the base of the Greenland Ice Sheet.*

A major unknown in assessing the response of ice sheets to climate change is the availability of meltwater to the bed in space and time. The formation of water-filled cracks beneath supra-glacial lakes is an effective mechanism to drive hydro-fractures through thick ice sheets and supply melt water to the bed. I will present both observational constraints on hydro-fracture formation beneath lakes in the Jakobshavn-Isbrae region of the Greenland Ice Sheet and theoretical calculations for the propagation of water-filled cracks. Specifically, I will show that supra-glacial lakes are required in order to store the volume of water necessary to maintain a water-filled crack until it reaches the bed. Once formed these fractures evolve into meltwater conduits (moulins) that remain open for the remainder of the summer melt season. Hydro-fracture events beneath supra-glacial lakes are correlated with transient (∼24 hr) horizontal acceleration and uplift of the ice sheet as the rapid influx of water overwhelms the basal hydrologic network, increasing water pressure, and reducing the shear stress at the bed. These transients place important constraints on the ability of the basal hydrologic system to evolve in response to changes in melt water supply. (Received December 15, 2010)

76 ► Fluid mechanics

1070-76-12 **Dharmendra Tripathi*** (dtripathi.rs.apm@itbhu.ac.in), Mathematic Group, BITS-Pilani, Hyderabad Camp, Hyderabad, 500078, India. *Peristaltic Transport of Fractional Oldroyd-B Fluids through the Channel.* Preliminary report.

A numerical study is designed to examine the peristaltic transport of fractional Oldroyd-B fluids through the channel. Analysis is carried out under the assumptions of long wavelength and low Reynolds number. Numerical and analytical approximate solutions of problem are obtained by using homotopy analysis method. It is assumed that the cross-section of the channel varies sinusoidally along the length of channel. The effects of fractional parameters, material constants (relaxation time and retardation time), time and amplitude on the pressure and friction force across one wavelength are discussed. It is found that the effect of both fractional parameters on pressure is opposite to each other i.e. pressure reduces with increasing the magnitude of first fractional parameter whereas it increases with increasing the second fractional parameter. The effects of relaxation time and retardation time on pressure are similar to that of first and second fractional parameters respectively. (Received November 07, 2010)

1070-76-32 **William R. Boos*** (william.boos@yale.edu), PO Box 208109, New Haven, CT 06520. *Towards a theory for where rain falls over tropical continents.* Preliminary report.

Despite decades of research, controls on the location, intensity, and variability of precipitation in the tropics are poorly understood. This is particularly true for tropical continental regions, which are home to developing nations and vulnerable agricultural economies. This talk will review the distribution of precipitation over tropical continents and present recent progress toward an understanding of the mechanisms controlling that distribution. Focus will be given to a theoretical framework in which nonlinear, planetary-scale circulations are thermodynamically coupled with the entropy of near-surface air by atmospheric moist convection; this framework allows assessment of the effects of ocean evaporation, topography, and land surface properties on tropical precipitation. Subseasonal variations in precipitation will also be examined, with emphasis on possible interaction between synoptic vortices and planetary-scale monsoon flow. Promising directions for improving our understanding and predictions of tropical continental rainfall will be discussed. (Received December 18, 2010)

1070-76-47 **Ellen R Peterson*** (ellenp@andrew.cmu.edu), Department of Mathematical Sciences, Wean Hall 6113, Carnegie Mellon University, Pittsburgh, PA 15208. *Behavior of a droplet of fluid on a thin liquid film.* Preliminary report.

We consider an initially uniform thin layer of fluid on a horizontal substrate. An aqueous droplet is then deposited on the layer and the spreading behavior is observed. The axisymmetric spreading of the droplet on the underlying fluid is modeled as two layer flow using the lubrication approximation. At the interface between the mucin layer, droplet, and air, a contact line discontinuity occurs. We track the location of the contact line and divide the solution into three components in terms of the interface: the mucin/air interface, the mucin/droplet interface, and the droplet/air interface. The system of fourth order nonlinear equations modeling the solution

consists of three partial differential equations (one for each interface) and an ordinary differential equation which tracks the location of the contact line. We further investigate the case where the lens spreads to a static state and how the solution changes as the surface tension of the fluids change. This investigation is a first step for an exploration of an aerosol drug treatment for cystic fibrosis patients. (Received January 03, 2011)

1070-76-53 **Kara L Maki*** (makia001@ima.umn.edu), Institute for Mathematics and Its Application, 114 Lind Hall, 207 Church Street SE, Minneapolis, MN 55455, and **Satish Kumar** (kumar030@umn.edu), Dept of Chemical Eng & Material Sciences, 151 Amundson Hall, 421 Washington Ave SE, Minneapolis, MN 55455. *Drying Droplets of Colloidal Suspensions: Role of Rheology.*

When a coffee droplet dries on a countertop, a dark ring of coffee solute is left behind, a phenomenon often referred to as "the coffee ring effect". The droplet initially has a uniform distribution of solute, but flow inside the droplet carries the solute to the droplet edges as evaporation occurs. A closely related yet less-well-explored phenomenon is the formation of a layer of particles, or skin, at the surface of the droplet. This phenomenon is highly relevant to the coating and drying of colloidal suspensions, and the goal of this work is to investigate the underlying mechanisms.

We consider the drying of a thin axisymmetric droplet of a colloidal suspension on a horizontal substrate. The fluid motion is described by applying the lubrication approximation to the momentum and mass conservation equations, and the transport of the particles is described using the full convection-diffusion equation. The particles are assumed to influence the rheology of the droplet through their effect on the suspension viscosity. The highly coupled governing system of equations is simulated using a finite-difference scheme based on a moving overset grid method. Preliminary findings along with future plans will be discussed. (Received January 11, 2011)

1070-76-97 **Robert H. Nazarian*** (rhnaza12@holycross.edu), 1 College Street, Box 1838, Worcester, MA 01610. *Mathematizing Tragedy: Creating a Fluid Dynamics Model to Foreshadow the Deepwater Horizon Oil Spill.*

On April 20, 2010 the course of our planet was irreversibly altered with the explosion of British Petroleum's Deepwater Horizon oil rig and the subsequent three-month flow of crude petroleum into the Gulf of Mexico. Immediately following the disaster, the government turned to scientists to reconcile the data and to use their analysis to motivate policy. While initial studies were unfruitful, new data infers that the poorly engineered Halliburton cement slurry installed in the Macondo well directly led to the demise of the rig and the subsequent oil spill. Furthermore, public and private data suggest that the faulty cement slurry, as well as other mechanical difficulties, were never integrated into a comprehensive model of the Macondo well and came together to create ideal conditions for disaster. My presentation will discuss the mathematizing of BP policy in addition to the appropriate changes that should have been made to the model due to challenging drilling conditions and the history of human error on the rig. In doing so, we will take an in-depth look at the fluid mechanics of the well to determine how the system approached disequilibrium. (Received February 07, 2011)

1070-76-184 **B. S. Tilley***, Dept. Mathematical Sciences - WPI, 100 Institute Road, Worcester, MA 01609, and **M. Bowen**, 3-8-1 Komaba, Meguro-ku, Tokyo, 153-8902, Japan. *Thermally induced van der Waals rupture of thin viscous fluid sheets.*

We consider the dynamics of a thin symmetric fluid sheet subject to an initial temperature variation. The sheet is assumed to be thick enough initially so that disjoining pressures are stabilizing, but these forces may become destabilizing when the thickness of the sheet becomes sufficiently thin during its evolution. We apply a long-wave analysis in the limit where deviations from the mean sheet velocity are small, but thermocapillary stresses and heat transfer from the sheet to the environment are significant. From a linear stability analysis, we find that a stable thermal mode couples the velocity and interfacial dynamics. We also find that the phase difference between the initial temperature and velocity distributions is a key parameter in determining the nonlinear stability of the fluid sheet and consequently the time of rupture. In particular, rupture can be induced thermally even in cases when the heat transfer to the surrounding environment is significant, provided that the initial phase shift between the initial velocity and temperature disturbances is close to $\phi = \pi/2$. (Received February 10, 2011)

1070-76-186 **Te-Sheng Lin**, Department of Mathematics, NJIT, **Linda Cummings**, Department of Mathematics, NJIT, and **Lou Kondic*** (kondic@njit.edu), Department of Mathematics, NJIT. *Modeling spreading of nematic liquid crystal droplets.*

Experiments by Poulard & Cazabat[1] on spreading droplets of nematic liquid crystal reveal a surprisingly rich variety of behavior, including at least two different emerging lengthscales resulting from a contact line instability. In earlier work[2] we modified a lubrication model for nematic liquid crystals due to Ben Amar and Cummings[3], and showed that, in a qualitative sense, it can account for much of the observed behavior. In the present work we propose a new approach, that allows us to explore the effect of anchoring variations on the substrate. This in turn gives a simple way to model the presence of defects, which are always present during such liquid crystal flows. The new model leads to additional terms in the governing equation. We first explore the influence of these additional terms for some simple flow scenarios, to gain a basic understanding of their influence, before extending our simulations to the experimental geometry and comparing our results to the experiments. (Supported by NSF grant DMS-0908158.) (Received February 10, 2011)

81 ► Quantum theory

1070-81-315 **Michael J. Falk*** (michael.falk@nau.edu), Dept. of Mathematics and Statistics, Flagstaff, AZ 86011-5717, and **Alexander N. Varchenko**. *Singular vectors for projective arrangements.*

We give a version of the contravariant form for weighted projective arrangements in homogeneous coordinates. Choosing a hyperplane at infinity yields an isomorphism of the space of singular flags with the singular subspace of the flag complex of the associated affine arrangement. (Received February 15, 2011)

83 ► Relativity and gravitational theory

1070-83-300 **James A Isenberg*** (isenberg@uoregon.edu), Department of Math, University of Oregon, Eugene, OR 97403, and **Xianghui Luo**. *Stability of a Class of Expanding Solutions of the Einstein-Maxwell-Scalar Field Equations.*

We generalize Ringstrom's global future causal stability results for certain expanding cosmological solutions of the Einstein-scalar field equations to solutions of the Einstein-Maxwell-scalar field system. In particular, we show that if we perturb (nonlinearly) the initial data for one of these model solutions, including electromagnetic as well as gravitational and scalar field perturbations, the maximal spacetime developments which evolve from such perturbed data retain the global (future complete) structure of the unperturbed model solutions. (Received February 15, 2011)

86 ► Geophysics

1070-86-2 **Kenneth M Golden*** (golden@math.utah.edu), University of Utah, Department of Mathematics, 155 S 1400 E RM 233, Salt Lake City, UT 84112-0090. *Mathematics and the melting polar ice caps.*

Polar ice is melting at an alarming rate – a strong signal that our climate is changing. In fact, most global climate models have significantly underestimated the dramatic decline of the summer Arctic sea ice pack. I will discuss how partial differential equations, dynamical systems, diffusion processes, and models from statistical physics are being used to help analyze the complex role of sea ice in the climate system. Key processes such as the melting and formation of seasonal ice must be better understood to improve projections of the fate of Earth's sea ice packs, and the response of polar ecosystems. Video and photos from recent Antarctic expeditions where we measured sea ice properties will be shown. (Received February 13, 2011)

1070-86-25 **Christopher Danforth*** (chris.danforth@uvm.edu), **Ross Lieb-Lappen**, **Nicholas Allgaier** and **Kameron D Harris**. *Dynamical Systems Approaches to Climate Prediction.*

Weather forecast models quickly diverge from observations as uncertainty in the initial state is amplified by nonlinearity. In contrast, Climate models typically drift apart due to uncertainty in the parameterizations required

[1] C. Poulard, A. M. Cazabat, Langmuir, 6270, vol. 21 (2005)
[2] L. J. Cummings, T.-S. Lin, L. Kondic, sumitted (2010)
[3] M. Ben Amar, L. J. Cummings, Phys. Fluids, 1160, vol. 13 (2001)

to make the model integration computationally feasible. Simple nonlinear models of atmospheric conditions will be used to describe recently developed techniques for extending the duration of useful simulations of the Earth's atmosphere, i.e. lengthening the shadowing time of the dynamical system. (Received December 13, 2010)

1070-86-30 **aviv solodoch**, weizmann inst, rehovot, Israel, **william r boos**, CT, **zhiming kuang**, acmbridge, MA , and **Eli Tziperman***, 20 oxford st, cambridge, MA 02138. *Excitation of slow MJO-like Kelvin waves in the equatorial atmosphere by Yanai wave-group via WISHE-induced convection.*

The intraseasonal Madden-Julian oscillation (MJO) involves a slow eastward-propagating signal in the tropical atmosphere which significantly influences climate yet is not well understood despite significant theoretical and observational progress.

We study the atmosphere's response to nonlinear "Wind Induced Surface Heat Exchange" (WISHE) forcing in the tropics using a simple shallow water atmospheric model. The model produces an interestingly rich interannual behavior including a slow, eastward propagating equatorial westerly multiscale signal, not consistent with any free linear waves, and with MJO-like characteristics. It is shown that the slow signal is due to a Kelvin wave nonlinearly forced by WISHE due to the meridional wind induced by a Yanai wave group. The forced Kelvin wave has a velocity similar to the group velocity of the Yanai waves, allowing the two to interact nonlinearly via the WISHE term while slowly propagating eastward. These results may have implications for observed tropical WISHE-related atmospheric intraseasonal phenomena. (Received December 16, 2010)

1070-86-90 **Hans G Kaper*** (kaper@mcs.anl.gov), 3335 Reservoir Rd, NW, Washington, DC 20007. *A Mathematician's Guide to the 2007 IPCC Report on Climate Change.*

"Climate Change 2007 – The Physical Science Basis" is the contribution of Working Group I to the Fourth Assessment Report of the International Panel on Climate Change (IPCC). At 996 pages, it is certainly no bedtime reading; nevertheless, it is an excellent source of information about scientific issues and concerns relevant to climate and climate change. In this talk I will highlight some findings of interest and indicate where mathematicians and statisticians might focus their attention. (Received February 01, 2011)

92 ► Biology and other natural sciences

1070-92-23 **Andrew D Barton*** (adbarton@mit.edu), Massachusetts Institute of Technology, 77 Massachusetts Ave, 54-1511, Cambridge, MA 02139, **Stephanie Dutkiewicz** (stephd@ocean.mit.edu), Massachusetts Institute of Technology, 77 Massachusetts Ave, 54-1412, Cambridge, MA 02139, **Glenn Flierl** (mick@ocean.mit.edu), Massachusetts Institute of Technology, 77 Massachusetts Ave, 54-1426, Cambridge, MA 02139, **Jason Bragg** (Jason.Bragg@csiro.au), CSIRO Plant Industry, Canberra, ACT 2601, Australia, and **Mick Follows** (mick@ocean.mit.edu), Massachusetts Institute of Technology, 77 Massachusetts Ave, 54-1514, Cambridge, MA 02139. *Patterns of Diversity in Marine Phytoplankton.*

Marine microorganisms, including phytoplankton, regulate the biogeochemical cycles of important elements in the climate system (C, N, P, Fe, and others), and there is an increasing appreciation that the total species diversity, in addition to the relative abundance of different species, determines the biogeochemical function of the ecosystem. Here, we examined the patterns and causes of marine phytoplankton diversity in a three-dimensional, time-varying global ocean circulation, biogeochemistry, and ecosystem model. Consistent with observations of marine and terrestrial ecosystems, the model indicated a decrease in phytoplankton diversity with latitude, which resulted from the seasonal variability of the physical environment. The relatively stable tropical and subtropical oceans allowed for the extended coexistence of phytoplankton with similar fitness, whereas the higher seasonality at higher latitudes led to the competitive exclusion of phytoplankton with slower growth rates and to lower diversity. Additionally, local "hot spots" of enhanced diversity were predicted in regions of energetic ocean circulation such as the Gulf Stream. These local diversity maxima reflected the role of ocean currents and mixing processes in the lateral dispersal of phytoplankton. (Received December 13, 2010)

1070-92-132 **Maria Sun Cavicchi***, MSCAVI11@holycross.edu, and **David Damiano**. *An Alternative Perspective for Modeling HIV.*

Patients in the chronic phase of HIV infection typically show heightened activation and lowered counts of CD4+ (helper) T cells (the primary target of HIV) and heightened activation and heightened counts of CD8+ (killer) T cells. For many patients, upon initiation of highly active anti-retroviral therapy (HAART), viral loads become undetectable within six months and activation levels and counts return to normal within two years. As part of

an ongoing retrospective study of data from the HIV/AIDS Clinic at the University of Massachusetts Medical School, we have analyzed CD4:CD8 ratios of patients with at least six years of virological and immunological response. While a majority of these patients have CD4 levels that plateau below normal, we have observed a continued immune response as measured by a sustained rise in CD4:CD8 ratio, which has not been reported in the literature. This is of potential clinical significance because it is counter to current clinical guidelines, which suggest that tracking CD4:CD8 ratios is not relevant. (Received February 06, 2011)

1070-92-156 **Ryan Elizabeth Prendergast*** (repren11@holycross.edu), 1 College Street, Box 2247, Worcester, MA 01610. *Determining the Rate Constant Matrix for a Two Compartment Pharmacokinetic Model.* Preliminary report.

When a drug enters the body, it undergoes a series of kinetic events, including absorption, distribution, metabolism, and elimination. Collectively, the study of these actions is known as pharmacokinetics. These actions occur in different compartments of the body, with the drug traveling through the bloodstream into different organs. The main purpose of our research is to develop a reliable method of estimating the rates at which drugs move from bloodstream to organ, or in our case tumor, and vice versa. In order to determine the most effective method, we developed a "simple" two-compartment model, one compartment representing the blood pool and the other being the tumor. We began with a predetermined rate constant matrix and found its eigenvalues and eigenvectors. Using these eigenvalues and eigenvectors, we created linear combinations of exponential functions to simulate bio-tracer mass data contained in each compartment. We then used various methods to estimate the rate constant matrix, utilizing linear regression and non-linear fitting coupled with spectral. Our goal was to determine the most reliable method, and subsequently to expand our findings to a multi-compartmental model, and ultimately apply our method to real data. (Received February 08, 2011)

1070-92-164 **Miao Wang*** (wangm@lafayette.edu), Box 9486, 111 Quad Drive, Lafayette College, Easton, PA 18042, and **Miranda Ijang Teboh-Ewungkem** (tebohewm@lafayette.edu), 3261 Highfield Drive, Bethlehem, 18020. *A Mathematical Perspective: How male fecundity affects the optimal gametocyte sex ratio of Plasmodium falciparum during incomplete fertilization.*

A mathematical model developed to simulate the within-vector dynamics of Plasmodium falciparum in an Anopheles mosquito is used to investigate how the ratios of the fecundities of double and triple parasite strains shift the optimal gametocyte sex ratio. For both the double-strain and the triple-strain cases, we showed that under random unbiased mating and incomplete fertilization, the sex ratio can be written as a function of the ratios of the fecundities under a cooperative gaming system. Moreover, the variation in the ratios of the fecundities led to a moderate variation in the optimal gametocytes sex ratio and also resulted in a more female biased sex ratio. Additionally, male biased sex ratios were observed under certain conditions when in addition to the difference in fecundities, the number of ingested gametocytes was different between strains. (Received February 08, 2011)

1070-92-342 **Joel C Miller***, 677 Huntington Ave, Boston, MA 02119, and **Erik M Volz**. *Epidemics on networks with just one equation.*

The structure of social interactions along which disease spreads can be represented using a network. When we investigate disease spread in networks we find that many mass action assumptions fail. Individuals with many contacts tend to become infected earlier, and in turn infect more individuals, leading to faster initial growth. However, the remaining population has fewer contacts than average, and so the growth rate decreases more rapidly and the epidemic dies out sooner than mass action predicts.

Unfortunately models tend to require many equations to correct this. Recent work by Volz (JMB 2008) found a low-dimensional system that exactly captures the dynamics. Work by Miller (JMB 2010) simplified this derivation and also simplified the equations.

Our more recent unpublished work simplifies the derivation further, and allows easy generalization to a wide range of diseases and population structures, including populations whose contacts change in time. The key simplification comes from focusing our attention on the fraction of edges connecting to susceptible, infected, or recovered individuals rather than the fraction of the population with each status. We show how to derive these systems and compare the resulting predictions with simulation. (Received February 16, 2011)

97 ► Mathematics education

1070-97-8 **Zane Wubbena*** (zane.wubbena@txstate.edu), 222 E. Riverside Dr. 114, Austin, TX 78704. *Cognitive Level of Development and Mathematical Fluency of First Grade Children.*

This study was designed to investigate the cognitive level of development and mathematical fluency of first grade children. A total of (N=100) 6 and 7-year-olds from two low-socio-economic elementary schools participated in this study. Jean Piaget's conservation-of-liquid experiment was administered to children to determine their cognitive level of development. A balanced between-subjects research design included a randomized sample of (n=50) nonconserving and (n=50) conserving children. Using a counterbalanced method, two single-skill Math Fact Probe instruments were administered separately for two-minutes to measure addition fluency and subtraction fluency. The results from a MANOVA indicated that conserving children had significantly greater addition fluency and subtraction fluency than nonconserving children. Post-hoc analysis revealed that age had a separate, but additional effect on mathematical fluency above and beyond cognitive level of development. The implications of this study indicated that cognitive level of development was not a grade level designation. The invariant levels of cognitive development were characterized by different abilities in mathematical fluency. (Received October 06, 2010)

1070-97-55 **Richard Bisk*** (rbisk@worcester.edu), Mathematics Department, 486 Chandler St., Worcester, MA 01541. *Improving the Mathematical Preparation of Elementary Teachers in Massachusetts.*

In 2007, the Massachusetts Board of Elementary and Secondary Education voted unanimously to upgrade the mathematical requirements for new elementary school teachers. The changes included a detailed document (www.doemass.org/mtel/mathguidance.pdf) that described "the breadth and depth of mathematics that teachers at the elementary level must not only be able to do, but understand and explain in many ways to students." Elementary teacher candidates now have to pass a separately scored mathematics test to earn certification.

This talk will describe the changes and the rationale behind them. The response of higher education, and in particular Worcester State University, will also be discussed. (Received January 18, 2011)

1070-97-89 **Catherine A Roberts*** (croberts@holycross.edu), Dept Mathematics and Computer Science, College of the Holy Cross, 1 College Street, Worcester, MA 01610. *The Intel Math Initiative: Professional Development to Deepen the Content Knowledge of our Nation's K-8 Teachers.*

The Intel Math Initiative is a nation-wide effort to move the needle on student mathematics achievement by deepening the content knowledge of K-8 teachers. Expansion of this 80-hour professional development course, generally delivered during the summer, relies on increasing the participation of college and university mathematics faculty. Come learn more about this opportunity to partner with K-8 teachers to increase their ability to teach mathematics effectively to our children. (Received February 01, 2011)

1070-97-96 **Corrine H. Taylor*** (ctaylor1@wellesley.edu), 106 Central Street, Wellesley, MA 02482. *Enhancing Quantitative Reasoning at the K-12 and College Levels of Education.*

How does "Quantitative Reasoning" differ from "Mathematics" *per se*? How have various colleges and universities sought to enhance their students' QR skills - students' ability to apply logic, math, and statistics in context and to strengthen their rhetoric with quantitative evidence? What efforts are being made at the K-12 level to infuse a QR approach in the curriculum? In this session, Corri Taylor draws on her experiences directing Wellesley College's QR Program for the past decade, running two-week "Improving Teacher Quality" professional development workshops on QR for secondary school teachers the last two summers, and enhancing the resources of the National Numeracy Network to address these questions. (Received February 01, 2011)

1070-97-110 **Wilfried Schmid*** (schmid@math.harvard.edu), Department of Mathematics, 1 Oxford Street, Cambridge, MA 02138. *Was it a good idea for Massachusetts to drop its own Mathematics Curriculum Framework and to replace it by the Common Core?*

In July, the Massachusetts Board of Education voted to replace the Massachusetts Curriculum Framework for Mathematics by the Common Core Mathematics standards. I shall briefly recount the history of the Common Core standards, and compare them to the Massachusetts Framework. I shall then discuss the reasons for and against this switch. Finally, I shall give my own personal answer to the question posed in my title. (Received February 02, 2011)

1070-97-159 **Andrew Chen*** (schen@edutron.com). *Some Trends in US K-12 Mathematics Education and What You Can Do To Help.*

The Common Core Standards are triggering cascading changes in K-12 curriculum, instruction, and assessment. K-12 mathematics education in US is going through a significant transformation. Mathematicians, in conjunction with mathematics educators, are invited to scrutinize the changing landscape and play an integral role in the process. What is called for to improve our K-12 mathematics education? What is the dominating term in this complex equation? What can I do about it? Bring your input and questions to the presentation and we will talk in plain English. As an example, the approach and outcomes of the EduTron Intensive Immersion Institutes will be described. (Received February 08, 2011)

1070-97-232 **Danuta Bukatko** and **David B. Damiano*** (dbd@mathcs.holycross.edu), Dept. of Mathematics and Computer Science, College of the Holy Cross, 1 College St., Worcester, MA 01610, and **Rosario D. Esparza**, **Sharon Frechette** and **Catherine Roberts**. *Foundational Mathematics Concepts for the High School to College Transition.*

The College of the Holy Cross was the recipient of a Massachusetts Department of Higher Education Improving Teacher Quality grant in 2010, with funds provided by the federal No Child Left Behind: Teacher and Principal Training and Recruiting Fund. The grant will support three, three-week summer workshops for middle and high school mathematics teachers from the City of Worcester and nearby districts focusing on aspects of the recently adopted Massachusetts Common Core of Learning and college readiness in mathematics. We will discuss the planning process and the mathematical content of the proposal as it relates to the Common Core and college readiness. (Received February 13, 2011)

1070-97-274 **Eileen F. Lee*** (elee@mathforamerica.org), Math for America-Boston, Mathematics and Statistics Dept;, Boston University, Boston, MA 02215. *Bridges Between High School and College Mathematics.* Preliminary report.

University mathematicians and high school mathematics teachers have much in common and collaboration is beneficial to both sides. In today's talk we will consider the value of collaboration in the areas of curriculum, teaching, and teacher preparation. We will look at opportunities and examples, some well established and others motivated by the Common Core State Standards and the growing need to recruit, train, and retain outstanding mathematics teachers. (Received February 14, 2011)

1070-97-277 **Steven J Miller*** (sjm1@williams.edu), Department of Mathematics and Statistics, Williams College, Williamstown, MA 01267, **Giuliana J Davidoff** (culiu22a@mtholyoke.edu), Department of Mathematics and Statistics, Mount Holyoke College, Williamstown, MA 01267, **John J Little** (culiu22a@mtholyoke.edu), Department of Mathematics & Computer Science, College of the Holy Cross, Williamstown, MA 01267, and **Amalia Culiuc** (culiu22a@mtholyoke.edu), Department of Mathematics and Statistics, Mount Holyoke College. *Panel on Undergraduate Research.*

After brief presentations by professors and students on what they have found works well (or not well) in undergraduate research, the rest of the time will be devoted to a moderated discussion for students and faculty on participating in and organizing successful undergraduate research in general and REUs in particular. (Received February 14, 2011)

1070-97-308 **AbdelNaser J. Al-Hasan*** (alhasan@msoe.edu), Mathematics Department, 1025 North Broadway, Milwaukee, WI 53202. *Effect of STEM Faculty Engagement in the K-12 System.*

In this talk I will discuss my contribution to the development of the new K-12 Common Core Mathematics Standards in the State of Wisconsin. I will also discuss my current involvement with a particular school district to implement a project that should help students who are interested in a STEM program succeed in an entry level math course such as Calculus I, and thus eliminate the need for remedial courses. (Received February 15, 2011)

03 ► Mathematical logic and foundations

1071-03-121 **Andrzej Roslanowski*** (roslanow@member.ams.org), Department of Mathematics, University of Nebraska at Omaha, Omaha, NE 68182-0243, and **Saharon Shelah**. *Monotone Borel hull operations for the meager and null ideals.*

Let I be an ideal of subsets of $\mathbb{R}$ with a Borel basis. A *monotone Borel hull operation* for I is a mapping $\phi : I \longrightarrow \text{Borel}(\mathbb{R})$ such that $\phi(A) \subseteq \phi(B)$ whenever $A \subseteq B \in I$. We are interested in the existence of monotone hull operations for the ideals $\mathcal{N}$ of Null and $\mathcal{M}$ of Meager subsets of $\mathbb{R}$.

Using the method of decisive creatures we show the consistency of "there is no increasing ω_2–chain of Borel sets and $\text{non}(\mathcal{N}) = \text{non}(\mathcal{M}) = \omega_2 = 2^\omega$". Hence, consistently, there are no monotone Borel hulls for the ideal $\mathcal{M} \cap \mathcal{N}$. (This answers a question of Balcerzak and Filipczak.) Also, we use FS iteration with partial memory to show that there may be monotone Borel hulls for the ideals $\mathcal{M}, \mathcal{N}$ even if they are not generated by towers. (Received February 27, 2011)

1071-03-153 **Steve Jackson*** (jackson@unt.edu), Dept. of Mathematics, Univ. of North Texas, Denton, TX 76203. *Stable homogeneous Trees.* Preliminary report.

We introduce the notion of a stable homogeneous tree and show assuming AD that every homogeneous tree on an ordinal $< \Theta$ is stable. A consequence of this is that we get a complete analysis of the scale property from just AD. (Received March 03, 2011)

1071-03-156 **Dima Sinapova***, dsinapov@math.uci.edu. *The tree property and failure of SCH for small cardinals.*

The tree property at κ^+ states that every tree with height κ^+ and levels of size at most κ has an unbounded branch. There is a tension between the tree property and the failure of the Singular Cardinal Hypothesis (SCH). Woodin and others asked if the failure of SCH at a singular κ implies the failure of the tree property at κ^+. Recently Neeman answered this question in the negative. Here we show that his result can be obtained at small cardinals. In particular, we will show that given ω many supercompact cardinals, there is a generic extension in which the tree property holds at $\aleph_{\omega^2+1}$ and SCH fails at $\aleph_{\omega^2}$. (Received March 03, 2011)

1071-03-159 **W Hugh Woodin*** (woodin@math.berkeley.edu), Professor W. Hugh Woodin, Department of Mathematics, UC Berkeley, Berkeley, CA 94720. *Coding with extenders.*

An important precursor to the fine-structural extender models of Mitchell and Steel, are the coarse extender models of Martin and Steel. We show that the coarse theory cannot be generalized to a theory of coarse coherent extender models with long extenders, in fact the counterexamples show that Martin-Steel Theory must fail if one allows extenders E of length $j_E(\kappa)+1$ where κ is the critical point of E and j_E is the ultrapower embedding associated to E. (Received March 03, 2011)

1071-03-201 **Jean A Larson***, Department of Mathematics, University of Florida, Gainesville, PO Box 118105, Gainesville, FL 32611-8105. *Partition Questions and Resources.* Preliminary report.

Some old and new problems about partitions are worth revisiting. I will discuss questions about a variety of partitions and will pinpoint resources for learning about them. (Received March 05, 2011)

1071-03-207 **Martin Zeman*** (mzeman@math.uci.edu), Department of Mathematics, University of California at Irvine, Irvine, CA 92697-3875. *Consistency results on stationary set reflection using modest large cardinal hypotheses.* Preliminary report.

Stationary set reflection has been extensively studied during past several decades, and many consistency results concerning stationary reflection at small cardinals have been established. It has been known that various instances of stationary reflection are of high consistency strengths and the consistency results were typically relative to the existence of large cardinals at the level of supercompactness. With the advance of inner model theory some modest large cardinal axioms were isolated; these are well below the weakest nontrivial instance of supercompactness. I will present some forcing constructions that use such large cardinals on the background and produce models with various forms of stationary set reflection. (Received March 06, 2011)

1071-03-212 **Theodore A. Slaman*** (slaman@math.berkeley.edu) and **Chris Conidis** (cconidis@math.uwaterloo.ca). *Random Reals and Arithmetic Conservation.* Preliminary report.

We investigate the question "To what are the number theoretic consequences to the existence of an infinite random sequence?" Let $2 - RAN$ be the principle that for every real X there is a real R which is 2-random relative to X. We will show that satisfying $2 - RAN$ imposes a regularity property $C\Sigma_2$ on the natural numbers N which could be set theoretically phrased as N's not being Σ_2 projectable. Then, we show that $2 - RAN$ is conservative over $RCA_0 + B\Sigma_2$ for Π^1_1-sentences, where $B\Sigma_2$ could be phrased as N's being Σ_2 regular. Though we are still looking for a model of first order arithmetic satisfying $I\Sigma_1 + C\Sigma_2$ and not satisfying $B\Sigma_2$, we will give a set theoretic argument to show the existence of a model with predicate X satisfying $I\Sigma_1(X) + C\Sigma_2(X)$ and not satisfying $B\Sigma_2(X)$. (Received March 06, 2011)

1071-03-220 **Itay Neeman***, UCLA Department of Mathematics, Los Angeles, CA 90095-1555. *Applications of forcing with sequences of models.*

We describe applications of forcing with sequences of models (Received March 06, 2011)

1071-03-228 **William J. Mitchell*** (wjm@ufl.edu), FL. *A sharp for the Chang model.*

The Chang model is the smallest model of ZF which contains the ordinals and all of its countable subsets. Woodin showed that the existence of a Woodin limit of Woodin cardinals implies the existence of a sharp for this model. I show that such a sharp follows from (at most) a cardinal κ such that $o(\kappa) = \kappa^{+\omega_1}$. (Received March 07, 2011)

1071-03-230 **Fred Galvin**, Department of Mathematics, THe University of Kansas, Lawrence, KS 66045, and **Marion Scheepers*** (mscheepe@boisesate.edu), Department of Mathematics, Boise State University, Boise, ID 83725. *On generalizations of Borel's Conjecture.* Preliminary report.

After a brief review of Borel's Conjecture we introduce a natural generalization. In the talk we present lower bounds and upper bounds on the consistency strength of instances of the generalized Borel Conjecture. (Received March 07, 2011)

1071-03-257 **Su Gao** and **Michael Ray Oliver*** (mike.r.oliver@gmail.com), 2049 Kent Drive, Los Altos, CA 94024. *Complexity of the isomorphism relation on quotient Boolean algebras.*

In my dissertation I proved that there are continuum-many Boolean algebras of the form $\mathcal{P}(\omega)/\mathcal{I}$, where $\mathcal{I}$ is a Borel ideal on ω. In fact somewhat more was proved, namely that the Borel equivalence relation E_0 was reducible to the isomorphism relation on such Boolean algebras.

Gao and I extended the result to show that any Borel equivalence relation whatever is reducible to this isomorphism relation. This talk sketches the proof and focuses on the role of certain ideals derived from other ideals, in a manner definable in their quotient Boolean algebras. (Received March 08, 2011)

1071-03-273 **Andreas R. Blass*** (ablass@umich.edu), Mathematics Dept., Univ. of Michigan, 2074 East Hall, 530 Church St., Ann Arbor, MI 48109-1043. *F_σ filters.* Preliminary report.

I plan to discuss some recent work concerning filters on ω that are F_σ subsets of the power set of ω. Much of this work was motivated by the use of such filters as conditions in a forcing that adjoins ultrafilters with interesting properties. Some of the results, however, do not mention forcing and are purely combinatorial facts about the filters themselves. (Received March 08, 2011)

1071-03-275 **Richard Ketchersid*** (richard.ketchersid@utdallas.edu), UT Dallas, Mathematics Department, 800 West Campbell Road, Richardson, TX 75080. *Lifting results on analytic/Suslin sets to ∞-Borel sets.* Preliminary report.

In joint work with A. Caicedo, we have lifted a variety of results which hold for analytic and, more generally, κ-Suslin sets, to the class of ∞-Borel sets under some additional assumptions. The method is quite general and derived from work of H. Woodin in the analysis/axiomatization of AD^+ models. The specific results we concentrate on were motivated by work of B. Miller and older work of G. Hjorth. (Received March 08, 2011)

1071-03-277 **Gunwon Lee*** (Lgnwn7@naver.com), #101 Yihwa Apt., Jongno-Ku, Seoul, 110-500, South Korea. *DENSE SUBALGEBRA READ AS A LINGISTIC MODEL.* Preliminary report.

Dense subalgebra with the compactness theorem was read as a linguistic model which justifies our use of algebra as the tool to measure the real life world, I think. However we have to accept that the number of the real outruns that of the expressed. The conjecture say the functional completeness of our language should accept the indirect speech acts in the natural science in addition to the ordinary language, I think (Received March 08, 2011)

05 ► Combinatorics

1071-05-35 **Richard Anstee*** (anstee@math.ubc.ca), Mathematics Department, #121-1984 Mathematics Rd., University of British Columbia, Vancouver, BC V6T 1Z2, Canada, and **Miguel Raggi** and **Attila Sali**. *Forbidden Configurations: Progress towards a Conjecture.*

Define a matrix to be simple if it is a (0,1)-matrix with no repeated columns. For a given (0,1)-matrix F, we say a matrix A has no *configuration* F if there is no submatrix of A which is a row and column permutation of F. Letting $|A|$ denote the number of columns in A, we define $\text{forb}(m, F) = \max\{|A| : A \text{ is } m\text{-rowed simple matrix with no configuration } F\}$. A conjecture of Anstee and Sali gives an integral valued function $f(F)$ and then claims that $\text{forb}(m, F)$ grows as $m^{f(F)}$. One value of the conjecture is that it predicts critical configurations F to consider. We describe some recently proven cases and some proof ideas. (Received January 23, 2011)

1071-05-46 **Florent Hivert** and **Anne Schilling***, Department of Mathematics, University of California, One Shields Ave, Davis, CA 95616, and **Nicolas M Thiery**. *The biHecke monoid of a finite Coxeter group and its representations.*

For any finite Coxeter group W, we introduce two new objects: its cutting poset and its biHecke monoid. The cutting poset, constructed using a generalization of the notion of blocks in permutation matrices, almost forms a lattice on W. The construction of the biHecke monoid relies on the usual combinatorial model for the 0-Hecke algebra $H_0(W)$, that is, for the symmetric group, the algebra (or monoid) generated by the elementary bubble sort operators. The authors previously introduced the Hecke group algebra, constructed as the algebra generated simultaneously by the bubble sort and antisort operators, and described its representation theory. In this paper, we consider instead the *monoid* generated by these operators. We prove that it admits $|W|$ simple and projective modules. In order to construct the simple modules, we introduce for each $w \in W$ a combinatorial module T_w whose support is the interval $[1, w]_R$ in right weak order. This module yields an algebra, whose representation theory generalizes that of the Hecke group algebra, with the combinatorics of descents replaced by that of blocks and of the cutting poset. (Received February 02, 2011)

1071-05-53 **Martin E. Malandro*** (malandro@shsu.edu). *Maximal Subgroups of Sandpile Monoids on Directed Graphs.*

The Abelian Sandpile Model is a mathematical model for diffusion that has captivated physicists and mathematicians since its introduction in 1987. The model is built on a directed graph with a distinguished vertex (called the sink) which is accessible from every other vertex. At each iteration of the dynamical system, a grain of sand is dropped on a random vertex, and once the number of grains on a non-sink vertex reaches its out-degree, the vertex topples, sending one grain along each of its outward edges. This can cause some or all of its neighbors to topple as well, forming an avalanche. The sink swallows all grains of sand sent to it and never topples.

Any two states of the system can be added by adding the number of grains on each vertex pointwise and allowing the system to avalanche if necessary, giving the system a monoid structure. Remarkably, the recurrent configurations of sand (those that appear in the dynamical system infinitely often with probability 1) have the algebraic structure of a group, and many questions about the evolution of the system have algebraic answers. Much of the work on the sandpile model to date has assumed the underlying graph is undirected. We study directed graphs and give a combinatorial description of every maximal subgroup of the monoid. (Received February 06, 2011)

1071-05-59 **Kiran Chilakamarri**, **Nathaniel Dean**, **Cong X Kang** and **Eunjeong Yi*** (yie@tamug.edu), P. O. Box 1675, Galveston, TX 77553. *Iteration Index of a Zero Forcing Set in a Graph.* Preliminary report.

Let each vertex of a graph $G = (V(G), E(G))$ be given one of two colors, say, "black" and "white". Let Z denote the (initial) set of black vertices of G. The *color-change rule* converts the color of a vertex from white to black if the white vertex is the only white neighbor of a black vertex. The set Z is said to be *a zero forcing set* of G if all vertices of G will be turned black after finitely many applications of the color-change rule. The *zero forcing*

number of G is the minimum of $|Z|$ over all zero forcing sets $Z \subseteq V(G)$. Zero forcing parameters have been studied and applied to the minimum rank problem for graphs in numerous articles. We define *the iteration index of a zero forcing set of a graph* G to be the number of (global) applications of the color change rule required to turn all vertices of G black; this leads to a new graph invariant, the *iteration index of* G – it is the minimum of iteration indices of all minimum zero forcing sets of G. We present some basic properties of the iteration index and discuss some preliminary results on certain graphs. (Received February 10, 2011)

1071-05-61 **Bonnie C Jacob*** (bcjntm@rit.edu). *Classification of nodes based on signal behavior in a network.*

Consider a network in which each node is designated as either "scattering" or "absorbing," thus determining the behavior of a signal as it travels through the node. The ability to classify nodes in the network based on the movement of a signal through the network depends on the structure of the network, the location of the different classes of nodes within the network, and the initial location of the signal.

In this talk, we will discuss how these factors influence our ability to recover the classification of the nodes. This discrete problem is based on the inverse problem of optical tomography, an imaging method. (Received February 11, 2011)

1071-05-67 **J A Verstraete*** (jacques@ucsd.edu), Department of Mathematics, 9500 Gilman Drive, La Jolla, CA 92093-0112, and **P Keevash** and **B Sudakov**. *Recent Progress on Bipartite Turán Numbers.*

Let $\mathcal{F}$ be a family of graphs. A graph is *$\mathcal{F}$-free* if it contains no copy of a graph in $\mathcal{F}$ as a subgraph. A cornerstone of extremal graph theory is the study of the *Turán number* $\mathrm{ex}(n, \mathcal{F})$, the maximum number of edges in an $\mathcal{F}$-free graph on n vertices. In this talk, I would like to give a summary of recent results on the case where $\mathcal{F}$ contains a bipartite graph. The problem of determining the order of magnitude of $\mathrm{ex}(n, \mathcal{F})$ in this case is notoriously difficult, even in the important cases where the forbidden family comprises a single cycle of even length or a particular complete bipartite graph. This class of problems has many applications in other areas of mathematics and in theoretic computer science, including combinatorial geometry, number theory, error-correcting codes, and so on to mention a few. The first paper giving a thorough approach to these problems is that of Erdős and Simonovits (1982), where a number of broad conjectures are made. In this talk I will address the status of these conjectures and some recent progress on each. (Received February 14, 2011)

1071-05-69 **Phong Châu**, **Louis DeBiasio*** (louis@mathpost.asu.edu) and **Hal Kierstead**. *Pósa's Conjecture.*

In 1962, Pósa conjectured that if G is a graph on n vertices with minimum degree at least $2n/3$, then G has a Hamilton square cycle (a Hamilton cycle with all 2-chords). In 1996, Komlós, Sárközy, and Szemerédi used the Regularity and Blow-up Lemmas to prove Pósa's Conjecture for graphs on at least n_0 vertices, where n_0 is a huge constant. Recently we proved Pósa's conjecture for graphs on at least 2×10^8 vertices using probabilistic techniques along with Fan and Kierstead's results from the 90's. (Received March 08, 2011)

1071-05-75 **Pranav G Anand** (panand@ucsc.edu), **Henry G Escuadro** (escuadro@juniata.edu), **Ralucca G Gera** (rgera@nps.edu), **Stephen G Hartke** (hartke@math.unl.edu) and **Derrick G Stolee*** (s-dstolee1@math.unl.edu). *On the hardness of recognizing triangular line graphs.*

Given a graph G, its triangular line graph is the graph $T(G)$ with vertex set consisting of the edges of G and adjacencies between edges that are incident in G as well as being within a common triangle. Graphs with a representation as the triangular line graph of some graph G are triangular line graphs, which have been studied under many names including anti-Gallai graphs, 2-in-3 graphs, and link graphs. While closely related to line graphs, triangular line graphs have been difficult to understand and characterize. Van Bang Le asked if recognizing triangular line graphs has an efficient algorithm or is computationally complex. We answer this question by proving that the complexity of recognizing triangular line graphs is NP-complete via a reduction from 3-SAT. (Received February 16, 2011)

1071-05-81 **Ralph J. Faudree** and **Ronald J. Gould*** (rg@mathcs.emory.edu), Department of Math and CS, Atlanta, GA 30322, and **Michael S. Jacobson**. *Minimum Degree and Disjoint Cycles in Claw-free Graphs.*

A graph is claw-free if it does not contain an induced subgraph isomorphic to $K_{1,3}$. Cycles in claw-free graphs have been well studied. In this paper we extend results on disjoint cycles in claw-free graphs satisfying certain minimum degree conditions. In particular, we prove that if G is claw-free of sufficiently large order $n = 3k$ with $\delta(G) \geq n/2$, then G contains k disjoint triangles. (Received February 20, 2011)

1071-05-89 **Andrew Crites*** (acrites@uw.edu), University of Washington, Department of Mathematics, Box 354350, Seattle, WA 98195-4350, and **Sara Billey** (billey@uw.edu), University of Washington, Department of Mathematics, Box 354350, Seattle, WA 98195-4350. *Pattern avoidance and affine Schubert varieties of type A.*

Schubert varieties in finite dimensional flag manifolds G/P are a well-studied family of projective varieties indexed by elements of the corresponding Weyl group W . In particular, there are many tests for smoothness and rational smoothness of these varieties. One key result due to Lakshmibai-Sandhya is that in type A the smooth Schubert varieties are precisely those that are indexed by permutations that avoid the patterns 4231 and 3412. Recently, there has been a flurry of research related to the infinite dimensional analogs of flag manifolds corresponding with G being a Kac-Moody group and W being an affine Weyl group or parabolic quotient. In this paper we study the case when W is the affine Weyl group of type A or the affine permutations. We develop the notion of pattern avoidance for affine permutations. Our main result is a characterization of the rationally smooth Schubert varieties corresponding to affine permutations in terms of the patterns 4231 and 3412 and the twisted spiral permutations. (Received February 22, 2011)

1071-05-110 **Grady Bullington**, **Linda Eroh*** (eroh@uwosh.edu), **Garry Johns** and **Steven J Winters**. *Knight's Tours Using External Squares.*

The classic puzzle of finding a closed knight's tour on a chessboard consists of moving a knight from square to square in such a way that it lands on every square once and returns to its starting point. The 8 x 8 chessboard can easily be extended to rectangular boards, and in 1991, A. Schwenk characterized all rectangular boards that have a closed knight's tour. More recently, Demaio and Hippchen investigated the impossible boards, and determined the fewest number of squares that must be removed from a rectangular board so that the remaining board has a closed knight's tour. The authors defined an extended closed knight's tour for a rectangular chessboard as a closed knight's tour that includes all squares of the board and possibly additional squares beyond the boundaries of the board, and answered the following question: How many squares must be added to a rectangular chessboard so that the new board has a closed knight's tour? In addition, the rectangular chessboards are revisited on the four surfaces: the torus, cylinder, Möbius strip, and the Klein bottle, and the fewest number of squares that must be removed or added to ensure a knight's tour are determined. (Received February 25, 2011)

1071-05-131 **Jozsef Balogh*** (jobal@math.uiuc.edu) and **John Lenz**. *On the Ramsey-Turan numbers of graphs and hypergraphs.*

Let t be an integer, $f(n)$ a function, and H a graph. Define the Ramsey-Turán number of H, $RT(n, H, f(n))$, to be the maximum number of edges in an n-vertex, H-free graph G with $\alpha(G) \leq f(n)$. Motivated by papers of Erdős, Hajnal, Simonovits, Sós, and Szemerédi, we shall investigate the Ramsey-Turán number of H for some graphs and hypergraphs H. It is joint work with John Lenz. (Received February 28, 2011)

1071-05-137 **Gretchen L. Matthews** and **Justin D. Peachey*** (jpeache@clemson.edu). *On Weierstrass semigroups arising from finite graphs.* Preliminary report.

In 2007, Baker and Norine proved an analogue of the Riemann-Roch Theorem for finite graphs. This result describes the dimension $r(D)$ of a divisor D on a finite graph G, where a divisor is an element of the free abelian group on the set of vertices of G. Motivated by the Weierstrass semigroup of a point on a nonsingular projective curve X, it is natural to consider the sets

$$H_r(P) = \{\alpha \in \mathbb{N} | r(\alpha P) = r((\alpha - 1)P) + 1\}$$

and

$$H_f(P) = \{\alpha \in \mathbb{N} | \exists f \in \mathcal{M}(G) \text{ such that } \Delta(f) = A - \alpha P \text{ where } A \geq 0\}.$$

If P is a point on a curve X and $r(\alpha P)$ is taken to be the dimension of the divisor αP, then these two sets are equal; indeed, $H_r(P)$ is well-studied Weierstass semigroup of P. However, in the graphical case where P is a vertex of a finite graph G, these two sets may not be equal. In this talk, we explore the relationship between these sets and provide several examples. (Received March 01, 2011)

1071-05-143 **Ryan Martin*** (rymartin@iastate.edu), 396 Carver Hall, Ames, IA 50011, and **Jason J Smith**, 396 Carver Hall, Ames, IA 50011. *Induced saturation number.* Preliminary report.

A graph G is H-saturated if G fails to have H as a subgraph, but the addition of any edge to G creates at least one copy of H as a subgraph.

The saturation number $\text{sat}(n, H)$ is the minimum size of an H-saturated graph on n vertices. In this talk, we define a version of saturation number suitable for induced subgraphs. This version is closely related to the notion of satisfiability of Boolean formulas.

We will provide bounds for this induced saturation number as well as establish the induced saturation number of some specific graphs. (Received March 02, 2011)

1071-05-146 **H. A. Kierstead*** (kierstead@asu.edu) and **A. V. Kostochka**. *Equitable list coloring of graphs with bounded degree.*

A graph G is equitably k-choosable if for every k-list assignment L there exists an L-coloring of G such that every color class has at most $\lceil |G|/k \rceil$ vertices. We prove results toward the conjecture that every graph with maximum degree at most r is equitably $(r+1)$-choosable. In particular, we confirm the conjecture for $r \leq 7$ and show that every graph with maximum degree at most r and at least r^3 vertices is equitably $(r+2)$-choosable. Our proofs yield polynomial algorithms for corresponding equitable list colorings. (Received March 02, 2011)

1071-05-149 **Fan Chung** (fan@ucsd.edu), 9500 Gilman Drive, La Jolla, CA 92093, and **Franklin Kenter*** (fkenter@math.ucsd.edu), 9500 Gilman Drive, La Jolla, CA 92093. *Discrepancy inequalities for directed graphs.* Preliminary report.

We establish several isopermetric inequalities concerning various types of discrepancies in a directed graph G. For any two given subsets of vertices, say S and T, we examine the 'flow' from S to T in the random walk on G at the state of the stationary distribution. In particular, we focus on the discrepancy which is the difference between the actual flow and the expected flow (which depends only the stationary distribution). We will show that the discrepancy of flows from S to T can be bounded above by using the eigenvalues of certain symmetric matrices associated with G. We also show that the maximum discrepancy can be bounded below by the same eigenvalues to within a logarithmic factor. In addition, we consider a variation of the discrepancy which concerns the difference between the flow from S to T and the flow from T to S. We will show that this variation of discrepancy can be similarly bounded from above and below by using eigenvalues of a skew-symmetric matrix associated with G. Furthermore, we introduce a quantum Laplacian which has complex-valued entries but is self-adjoint. We will illustrate that the eigenvalues of the quantum Laplacian can be used to capture several types of discrepancies. (Received March 02, 2011)

1071-05-150 **Michael Ferrara*** (michael.ferrara@ucdenver.edu), University of Colorado Denver, Denver, CO 80217, and **Michael Jacobson**, **Kevin Milans**, **Craig Tennenhouse** and **Paul Wenger**. *Saturation Numbers for Families of Graph Subdivisions.*

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

In this talk, we consider $sat(n,\mathcal{S}(H))$ when H is one of C_t or K_t, obtaining several exact results and bounds. In particular, we determine $sat(n,\mathcal{S}(C_t))$ exactly for $3 \leq t \leq 5$ and show for n sufficiently large that there exists a constant c_t such that $\frac{5}{4}n \leq sat(n,\mathcal{S}(C_t)) \leq \left(\frac{5}{4}+\frac{c_t}{t}\right)n$. We also give an upper bound on $sat(n,\mathcal{S}(K_t))$ for all t and show that $sat(n,\mathcal{S}(K_5)) = \lceil \frac{3n+4}{2} \rceil$. (Received March 02, 2011)

1071-05-162 **Jonathan Cutler*** (cutlerjo@mail.montclair.edu), Department of Mathematical Sciences, Montclair State University, One Normal Avenue, Montclair, NJ 07043, and **A. J. Radcliffe**. *Extremal problems for homomorphisms.*

There has recently been quite a bit of interest in problems related to minimizing or maximizing the number of homomorphisms among graphs in some class into a fixed (small) graph. For example, it is a consequence of the Kruskal-Katona theorem that the number of independent sets in a graph on a fixed number of vertices and edges is maximized by the lex graph. This talk will outline several results that are the product of joint work with A.J. Radcliffe, including the minimization of the number of independent sets and the maximization of the number of split subgraphs in graphs of fixed order and size. (Received March 03, 2011)

1071-05-168 **Amites Sarkar*** (amites.sarkar@wwu.edu), Department of Mathematics, Western Washington University, 516 High Street, Bellingham, WA 98225, and **Martin Haenggi**. *Coverage and Percolation in Random Geometric Graphs.*

Place a billion black points and a million red points uniformly at random in a large disc D. Now grow a disc about each black point until it hits the nearest red point. What is the expected proportion of D that is covered by the small discs? What is the probability that D is entirely covered? These questions were inspired by the issue of security in wireless networks. I'll present some partial solutions, and also discuss a related percolation question. This is joint work with Martin Haenggi. (Received March 03, 2011)

1071-05-172 **Bela Csaba*** (bela.csaba@wku.edu), Dept. of Mathematics, 1906 College Heights Blvd., Bowling Green, KY 42101, and **Asif Jamshed** and **Endre Szemeredi**. *Embedding Spanning Trees.*

There exist two positive constants c and K such that the following holds. Let T be a tree on n vertices with maximum degree $m \leq cn/\log n$. Let G be a graph on n vertices having minimum degree $\delta(G) \geq n/2 + Km\log n$. If n is sufficiently large then $T \subset G$. (Received March 03, 2011)

1071-05-186 **Hao Huang*** (huanghao@math.ucla.edu), Los Angeles, CA 90024, and **Benny Sudakov** and **Noga Alon**. *Nonnegative k-sums, fractional covers, and probability of small deviations.*

More than twenty years ago, Manickam, Miklós, and Singhi conjectured that for any integers n, k satisfying $n \geq 4k$, every set of n real numbers with nonnegative sum has at least $\binom{n-1}{k-1}$ k-element subsets whose sum is also nonnegative. In this talk we discuss the connection of this problem with matchings and fractional covers of hypergraphs, and with the question of estimating the probability that sum of certain independent random variables deviates from its expectation. Using these connections together with some probabilistic techniques, we verify the conjecture for $n \geq 33k^2$. This substantially improves the best previously known exponential lower bound $n \geq e^{ck\log\log k}$. (Received March 04, 2011)

1071-05-189 **Eric Lars Sundberg*** (sundberg@oxy.edu), Occidental College, 1600 Campus Road, Los Angeles, CA 90041. *Extremal Systems for the Fair and Biased Erdős-Selfridge Theorem.*

Positional game theory studies combinatorial games of complete information. It is perhaps easiest to think of positional games as generalizations of tic-tac-toe where the game board is an arbitrary hypergraph. (The vertices of the hypergraph are the "positions" that the two players occupy, and the edges of the hypergraph are the "winning sets.") In this talk we will discuss a pivotal theorem in positional game theory by Erdős and Selfridge, and some of its extremal systems. (Received March 04, 2011)

1071-05-192 **Fan Chung** and **Stephen J Young*** (s7young@math.ucsd.edu). *Diameter of Random Cubic Sum Graphs.* Preliminary report.

A random cubic sum graph is formed by selecting each element of $\mathbb{Z}_2^k - \{\mathbf{0}\}$ with probability p and defining two elements u and v to be adjacent if $u+v$ has also been selected. Beveridge recently showed that the connectivity threshold for this random graph occurs at $p = \sqrt{\frac{\log(n)+\log(\log(n))}{n}}$, where $n = 2^k - 1$. For p slightly above the connectivity threshold we show that diameter of random cubic sum graphs is concentrated on one of four values with high probability. (Received March 05, 2011)

1071-05-194 **Michael S Jacobson*** (michael.jacobson@ucdenver.edu). *Minimum Degree and Disjoint Cycles in Generalized Claw-free Graphs.*

For $s \geq 3$ a graph is $K_{1,s}$-free, if it does not contain an induced subgraph isomorphic to $K_{1,s}$. Cycles in $K_{1,3}$-free graphs, called claw-free graphs, have been well studied. In this paper we extend results on disjoint cycles in claw-free graphs satisfying certain minimum degree conditions to $K_{1,s}$-free graphs, normally called generalized claw-free graphs. In particular, we prove that if G is $K_{1,s}$-free of sufficiently large order $n = 3k$ with $\delta(G) \geq n/2 + c$ for some constant $c = c(s)$, then G contains k disjoint triangles. Analogous results with K_3 replaced by a complete graph K_m for $m \geq 3$ will be discussed. Also, the existence of 2-factors for $K_{1,s}$-free graphs with minimum degree conditions will be shown. (This is joint work with R. Faudree and R. Gould) (Received March 05, 2011)

1071-05-200 **Jacob Fox** and **Choongbum Lee*** (abdesire@ucla.edu), Los Angeles, and **Benny Sudakov**. *Maximum union-free subfamilies.*

A family of sets is called union-free if there are no three distinct sets in the family such that the union of two of the sets is equal to the third set. We prove that every family of m sets contains a union-free subfamily of size at least $[\sqrt{4m+1}] - 1$ and that this bound is tight for all m. This solves an old question of Moser and proves a conjecture of Erdos and Shelah from 1972.

More generally, a family of sets is *a-union-free* if there are no $a+1$ distinct sets in the family such that one of them is equal to the union of a others. We determine up to an absolute multiplicative constant factor the size of the largest guaranteed a-union-free subfamily of a family of m sets. Our result verifies in a strong form a conjecture of Barat, Füredi, Kantor, Kim and Patkos. The proof makes use of an extension of Dilworth's theorem which might be of independent interest.

Joint work with Jacob Fox and Benny Sudakov (Received March 05, 2011)

1071-05-202 **Steve Butler*** (butler@math.ucla.edu) and **Ron Graham** (graham@ucsd.edu). *Marking lines in $[k]^n$.*

In $[k]^n = [k]\times[k]\times\cdots\times[k]$, a coordinate line consists of the collection of points where all but one coordinate is fixed and the unfixed coordinate varies over all possibilities. We consider the problem of marking (or designating) one point on each coordinate line in $[k]^n$ so that each point in $[k]^n$ is marked either a or b times, for some fixed a or b. We show that for $k = 2$ or $n \leq 5$ that the necessary conditions, i.e., there are integers $s, t \geq 0$ so that $s + t = k^n$ (the number of points) and $as + bt = nk^{n-1}$ (the number of lines), are also sufficient for the existence of such a marking. (Received March 05, 2011)

1071-05-209 **Peter Allen**, **Graham Brightwell** and **Jozef Skokan*** (jozef@member.ams.org). *Ramsey-goodness.*

Given two graphs G and H, the Ramsey number $R(G, H)$ is the smallest N such that, however the edges of the complete graph K_N are colored with red and blue, there exists either a red copy of G or a blue copy of H. Burr gave a simple general lower bound on the Ramsey number $R(G, H)$, valid for all connected graphs G: defining $\sigma(H)$ to be the smallest size of any color class in any coloring of H with $\chi(H)$ colors, we have $R(G, H) \geq (chi(H) - 1)(|G| - 1) + \sigma(H)$. For a given graph H, it is natural to ask which connected graphs G attain this bound. A class of graphs is called Ramsey-good if, for each fixed H, Burr's bound is attained for all sufficiently large graphs G in the class.

In this talk we will give an overview of some known results about Ramsey-goodness, and offer some new results. In particular, we shall explore connections between Ramsey-goodness and the bandwidth. (Received March 06, 2011)

1071-05-218 **Daniela Ferrero*** (dferrero@txstate.edu), 601 University Drive, Department of Mathematics, Texas State University, San Marcos, TX 78666. *Power domination and zero forcing in graphs.* Preliminary report.

The power domination problem arises in the study of the monitoring process of power networks modeled by graphs. Given a graph and a subset of vertices, at the initial state the set monitors its closed neighborhood. Then, the following rule applies: if a monitored vertex has exactly one non-monitored neighbor, the non-monitored neighbor becomes monitored. The application of this rule is iterated until it no longer detects new vertices to be monitored. At that point, if all the vertices are monitored, the initial set is a power dominating set (PDS). The power domination problem consists of finding a minimal PDS for a given graph.

The zero-forcing problem can be formulated in a similar way. Consider a graph whose vertices are arbitrary colored in black or white. Then, if a white vertex is the only white neighbor of a black vertex, its color should be changed to black. The application of this rule is iterate until it does not change the color of any vertex. At the end of this process, if all vertices are black, the initial set of black vertices is called a zero-forcing set (ZFS). The zero-forcing problem consists of finding a minimal ZFS for a given graph.

Combining some known results on power domination and on zero-forcing, we obtain minimal PDS for some families of graphs. (Received March 06, 2011)

1071-05-219 **Younjin Kim*** (ykim36@illinois.edu), Mathematics Dept., University of Illinois, Urbana, IL 61801, and **Zoltan Furedi**. *On random graphs with given diameter.*

A random graph is a graph with each pair of vertices connected by an edge independently with probability p, where $0 < p < 1$ is fixed. In 1995, Grable proved that for all $2 \leq d \ll \sqrt{n}/\log n$,

$$\mathrm{Prob}(\mathrm{diam}(G) = d | \mathrm{diam}(G) \geq d) \to 1$$

as $n \to \infty$, where $0 < p < 1$. We proved that the same result holds for almost all d and n, where $\frac{1}{2} \leq p < 1$, by finding the typical random graph classes to which almost all n-vertex random graphs of diameter of at least d with edge probability p belong. In the case $(n - d - 1)p > c_1 \log d$ the typical graph of diameter d consists of a combination of an induced path of length d and a highly connected block of size $n - d + 3$. In the case $(n - d - 1)p < c_2 \log d$ the typical graph has a completely different snakelike structure. This is a joint work with Zoltán Füredi. (Received March 06, 2011)

1071-05-231 **Gabor Kun***, DIMACS Center/CoRE Building/4th Floor Rutgers, Piscataway, NJ 08854, and **Bela Bollobas** and **Imre Leader**. *Cops and robbers in random graphs.*

We will study the following game known as cops and robbers. There is a finite, connected, undirected graph G, and m cops and one robber. At the start, each cop chooses one vertex, and then the robber makes his choice of a vertex. Then they move alternately (first the cops then the robber). In the cops' turn, each cop may move to an adjacent vertex, or remain where he is, and similarly for the robber. The cops win the game if one of the cops catches the robber, i.e. lands on the same vertex. We denote by $c(G)$ the 'cop-number' of G, meaning the

minimal m such that m cops have a winning strategy in G, and by $c(n)$ the maximum of $c(G)$ over all graphs with n vertices. Maamoun and Meyniel determined the cop-number for grids. Aigner and Fromme proved that in the case of planar graphs three cops can catch the robber. Frankl gave lower bounds on $c(G)$ in the case of large girth graphs. Meyniel conjectured that $c(n) = O(\sqrt{n})$. Our main aim is to prove that the conjecture essentially holds for sparse random graphs: in this case the cop-number has order of magnitude $\Omega(n^{1/2+o(1)})$. Joint work with Bela Bollobas and Imre Leader. (Received March 07, 2011)

1071-05-232 **Silvia Fernández-Merchant*** (Silvia.Fernandez@csun.edu), Department of Mathematics, 18111 Nordhoff Street, Norhridge, CA 91330-8313, and **Bernardo M. Ábrego** and **Canek Peláez**. *Maximizing the number of k-sets.* Preliminary report.

Let P be a set of n points in general position in the plane. For $k \leq n/2$, a *k-set* of P is a set $Q \subseteq P$ with k elements that can be separated from $P \setminus Q$ by a straight line. In this talk we consider the problem of maximizing the number of k-sets that can be generated by a set of n points in general position in the plane. The exact maximum for the number of 2-sets was known and the upper and lower bounds for 3-sets were one unit apart. We determine the exact maximum for 3-sets and we provide new bounds for other small values of k. (Received March 07, 2011)

1071-05-234 **Bernardo M. Ábrego*** (Bernardo.Abrego@csun.edu), Department of Mathematics, 18111 Nordhoff Street, Northridge, CA 91330-8313, and **Ruy Fabila-Monroy**, **Silvia Fernández-Merchant**, **David Flores-Peñaloza**, **Ferran Hurtado**, **Vera Sacristán** and **Maria Saumell**. *On crossing numbers of geometric proximity graphs.*

Let P be a set of n points in the plane. A *geometric proximity graph* on P is a graph where two points are connected by a straight-line segment if they satisfy some prescribed proximity rule. We consider four classes of higher order proximity graphs, namely, the k-nearest neighbor graph, the k-relative neighborhood graph, the k-Gabriel graph and the k-Delaunay graph. For $k = 0$ ($k = 1$ in the case of the k-nearest neighbor graph) these graphs are plane, but for higher values of k they contain crossings. In this talk we provide lower and upper bounds on their minimum and maximum number of crossings. We give general bounds and we also study particular cases that are especially interesting from the viewpoint of applications. These cases include the 1-Delaunay graph and the k-nearest neighbor graph for small values of k. (Received March 07, 2011)

08 ► General algebraic systems

1071-08-126 **Benjamin Wells*** (wells@usfca.edu). *An improved pseudorecursive property of finite spectra.* Preliminary report.

For a first-order sentence s, its spectrum $\mathrm{Sp}(s) = \{|A| \in \omega : A \models s\}$ is cofinite or $\mathrm{Sp}(\neg s)$ is cofinite. From a finite pseudorecursive equational base Φ_1 (defined in [1]) we derive sets $E' \supset T'$ of sentences. Those involving no more than n variables form E'_n. 'Cofinite' distinguishes this result from [1, 6.5].

Theorem. 1. $E', E'_n (n \in \omega)$ are infinite recursive sets. T' is r.e., but not recursive.
2. For $s \in E'$, $\mathrm{Sp}(s)$ is cofinite if $s \in T'$, and empty otherwise.
3. For all sufficiently large n, there are infinitely many $s, t \in E'_n$ with empty $\mathrm{Sp}(s)$ and cofinite $\mathrm{Sp}(t)$.
4. Given n, there is a TM that on input of $s \in E'_n$ answers whether $\mathrm{Sp}(s)$ is empty or cofinite.
5. No TM, on input of n and $s \in E'_n$, answers whether $\mathrm{Sp}(s)$ is empty or cofinite.
6. No TM, on input of $s \in E'$, answers whether $\mathrm{Sp}(s)$ is empty or cofinite.

We add disheveled elements (dsh, called 'deesh') that are idempotent but otherwise zeroes. Once a finite model of a sentence in E' exists, then it has models of any higher finite cardinality by simply looking for more dsh.

[1] B. Wells, Applying, abstracting, extending, and specializing pseudorecursiveness, APAL 126 (2004), 225-254 (Received February 28, 2011)

1071-08-245 **Nantel Bergeron*** (bergeron@yorku.ca), Dept. of Math. and Stat, York University, 4700 Keele st, Toronto, Ontario M3J 1P3, Canada, and **Chris Berg**, **Sandeep Bhargava** and **Franco Saliola**. *Primitive Orthogonal Idempotents for R-trivial monoids.*

We show that the notions of R-trivial monoid and weakly ordered monoid are equivalent. We use this fact to construct a recursive formula for a complete system of orthogonal idempotents for any R-trivial monoid. (Received March 07, 2011)

11 ► Number theory

1071-11-41 **Vijayarangan Natarajan*** (n.vijayarangan@tcs.com), No 17 Cathedrasl Road, Chennai, 600086, India. *Applications of Number theory - Information Security and Mobile Computing.* Preliminary report.

The following results derived out of Number theory with some open problems are to be discussed in this talk.

Application 1: In the theory of Double Base Number System (DBNS) / Multiple Base Number System (MBNS), finding the best approximation for a given integer is a hard problem. This approximation can be used to compute Elliptic curve scalar multiplication in an efficient way. In this presentation, we outline an algorithm for DBNS, which expresses any integer n in the form of DBNS with decreasing order of exponents.

Application 2: We have introduced a system and method of extensible authentication protocols (EAPs) based on ECC and SKE methods with a proper permutation technique evolved. The permutation in our EAPs is a process of cubing a random number w.r.to a prime (= 2 mod 3). These EAPs are compatible with 3G and 4G networks and no certificates exchanged during the communication. Further, they play an important role to fulfill CAAA issues. (Received January 28, 2011)

1071-11-43 **Boris Adamczewski** and **Jason P Bell*** (jpb@math.sfu.ca), Department of Mathematics, Simon Fraser University, 8888 University Dr., Burnaby, BC V5A 1S6. *On the set of zero coefficients of an algebraic power series.*

Let K be a field of positive characteristic p and let

$$F(x) = \sum_{n=0}^{\infty} f(n)x^n \in K[[x]]$$

be the power series expansion of an algebraic function. We consider the set S of natural numbers n for which $f(n) = 0$. We show that there is aa finite-state automaton that accepts as input the base p expansion of n and this automaton accepts n if and only if n is in S. We show how many interesting Diophantine questions in positive characteristic can be answered effectively using this result. (Received January 29, 2011)

1071-11-77 **Kalyani K. Madhu*** (kkmadhu@math.rochester.edu). *The Proportion of Periodic Points in $\mathbb{F}_p$.*

Let $f(x) = x^m + c$ be a polynomial in $\mathbb{F}_p[x]$. The orbit of any $\alpha \in \mathbb{F}_p$ under iteration of this map is finite; thus α is necessarily preperiodic. We consider the proportion of strictly periodic $\alpha \in \mathbb{F}_p$ and show that for certain classes of primes $p \in \mathbb{Z}$, the proportion of periodic α in $\mathbb{F}_p$ tends to zero as p becomes arbitrarily large. Our technique is to identify the Galois groups of the successive splitting fields of $f^n(x) - t$ over $\mathbb{F}_p(t)$, and to draw conclusions using Chebotarev's Density Theorem for function fields, similar to the technique used by Jones for quadratic polynomials over $\mathbb{Z}$ and Odoni for generic polynomials over number fields.
(Received February 17, 2011)

1071-11-164 **Jason Bell** and **Kevin Doerksen*** (kdoerkse@sfu.ca), Department of Mathematics, Simon Fraser University, 8888 University Dr., Burnaby, BC V5A 1S6, Canada. *On the prime divisors in zero orbits of polynomials.* Preliminary report.

Let $(b_n) = (b_1, b_2, \dots)$ be a sequence of integers. A primitive prime divisor of the k-th term is a prime which divides b_k but does not divide any previous term in the sequence. A zero orbit of a polynomial $\varphi(z)$ is a sequence of integers (c_n) where the n-th term is the n-th iterate of φ at 0. We consider primitive prime divisors of zero orbits of polynomials. Let $d \geq 2$ and let $\phi(x) = a_d x^d + \cdots + a_2 x^2 + a_0$ be an integer polynomial of degree d. Then we define the integer sequence (b_n) by $b_n = \phi^n(0)$. In this talk, we show that if zero has an infinite orbit, then b_n will have primitive prime divisors for all $n \geq 3$.

We also give conditions on the coefficients of the polynomial which determine whether the primitive prime divisors will begin appearing in the zero orbit by the first, second, or third term. Together with an earlier result by Rice, this gives a complete breakdown of whether a polynomial with no linear term will have a finite zero orbit or an infinite zero orbit, and in the latter case, whether the primitive prime divisors begin appearing by the first, second, or third term of the sequence.

This talk is based on joint work with Jason Bell and builds on previous joint work with Anna Haensch. (Received March 03, 2011)

1071-11-181 **Arthur Baragar*** (baragar@unlv.nevada.edu), Department of Mathematical Sciences, University of Nevada, Las Vegas, Box 454020, 4505 Maryland Parkway, Las Vegas, NV 89154-4020. *A lattice point problem on hyperboloids of one sheet.* Preliminary report.

Lattice point problems on hyperboloids of one sheet have not received the same attention as those on hyperboloids of two sheets, since lattice points on the former do not have a natural interpretation as lattice points in hyperbolic geometry (though there is an interpretation as lines). In this talk we look at particular conditions that significantly simplify the problems. The conditions have natural interpretations in arithmetic geometry – the "height" we use is ample, and the lattice points outside the light cone (so on hyperboloids of one sheet) are required to be inside the effective cone. (Received March 04, 2011)

1071-11-182 **Vijay Sookdeo*** (vjsookdeo@gmail.com), Department of Mathematics, The Catholic University of America, 620 Michigan Ave NE, Washington, DC 20064. *The Backward Orbits Conjecture.*

J. Silverman proved that a forward orbit of a rational function f(x) with rational coefficients contains at most finitely many integers when f(f(x)) is not a polynomial. We state a similar conjecture for the backward orbits using a more general notion integrality, and discuss the current results pertaining to it. (Received March 04, 2011)

1071-11-183 **Xander Faber** and **Michelle Manes*** (mmanes@math.hawaii.edu), University of Hawaii, Department of Mathematics, 2565 McCarthy Mall, Keller 401A, Honolulu, HI 96822. *Berkovich dynamics of certain quadratic rational maps.* Preliminary report.

A quadratic rational map with a nontrivial automorphism is necessarily conjugate (over an algebraically closed field) to one of the form $\phi(z) = t(z + 1/z)$. We describe properties of the dynamics of this map that are valid for all parameters t. The analytic behavior of the dynamics is completely determined by whether $|t|$ is less than, equal to, or exceeds 1. We never make explicit use of the fact that this map has a nontrivial automorphism; instead, we seem to benefit from the fact that the two critical points are interchanged by automorphism of order 2, so the dynamics of the two points must be the same. (Received March 04, 2011)

1071-11-239 **Bianca A. Thompson***, 822 Kahuna Ln, Honolulu, HI 96826. *Bounding Preperiodic Points for Some Twisted Families of Rational Maps.* Preliminary report.

Let ϕ be a quadratic rational map with a unique fixed point defined over number field K. A priori this is a one-parameter family. However, all such maps are conjugate over $\bar{K}$ to $\phi(z) = z + \frac{1}{z}$. Using standard techniques from arithmetic dynamics, we obtain uniform bounds on preperiodic points for this family. (Received March 07, 2011)

1071-11-253 **Rafe Jones*** (rjones@holycross.edu). *Reducible arboreal Galois representations.*

By an arboreal Galois representation, we mean the Galois group of the splitting field of all iterates of a rational function defined over a number field. Just as the p-adic Galois representation attached to an elliptic curve has a natural filtration given by action on the p^n torsion for each n, an arboreal representation has a natural filtration given by the action on the roots of the nth iterate of the rational function. In the elliptic curve case, a surjective action on the p^n torsion for very small n implies that the full p-adic representation is surjective. We give evidence that there is no such phenomenon for aboreal representations. One result is that for any n there is a quadratic polynomial defined over $\mathbb{Q}$ with transitive Galois action for all iterates up to n, but intransitive action on the $(n + 1)$st iterate. (Received March 08, 2011)

1071-11-261 **Patrick Ingram*** (pingram@math.uwaterloo.ca). *Post-critically finite polynomials.*

We will discuss some recent work on characterizing post-critically finite polynomial dynamical systems. (Received March 08, 2011)

1071-11-270 **Katherine E Stange*** (stange@math.stanford.edu), Stanford University, Department of Mathematics, Building 380, Stanford, CA 94305, and **Michelle Manes**. *Dynamical Units.* Preliminary report.

Narkiewicz and Morton–Silverman defined dynamical units in analogy to cyclotomic and elliptic units. These are units in the number field generated by n-periodic points of a rational map, which can be described explicitly (along with the action of Galois) in terms of the points and the map. We describe some new dynamical units and investigate the dynamical unit group in certain fields. (Received March 09, 2011)

1071-11-283 **Alice Medvedev*** (alice@math.berkeley.edu) and **Thomas Scanlon**. *Zhang's Conjecture for upper-triangular polynomial dynamical systems on $\mathbb{A}^n$.* Preliminary report.

Shou-Wu Zhang conjectured that nice algebraic dynamical systems $F : X \to X$ have points whose orbits under F are Zariski-dense in the underlying variety X. The other possibility is that the Zariski closure of the orbit is an F-invariant subvariety of X. One example of nice dynamical systems (very different from the sort of nice that Zhang had in mind) is *upper-triangular polynomial dynamical systems*, where $X = \mathbb{A}^n$ and

$$F(x_1, x_2, \dots x_n) = (f_1(x_1), f_2(x_1, x_2), \dots f_n(x_1, x_2, \dots x_n))$$

for some polynomial $f_i \in K[x_1, \dots x_i]$. Our previous results on product dynamical systems and a few observations about periodic points yield enough information about F-invariant varieties to produce points in the algebraic closure of K whose F-orbits are Zariski-dense in $\mathbb{A}^n$. (Received March 08, 2011)

13 ► Commutative rings and algebras

1071-13-27 **Ann Johnston*** (ajohnston@hmc.edu), **Michael Orrison** (orrison@hmc.edu) and **Michael Hansen** (mhansen@gmail.com). *Markov Bases for Noncommutative Harmonic Analysis of Partially Ranked Data.* Preliminary report.

In their 1998 paper, Persi Diaconis and Bernd Sturmfels introduced a technique for determining the significance of different summary statistics on a data set, given a fixed summary statistic, that uses a Markov process to generate a representative sample space conditioned on the fixed statistic. This method has been used in studying fully ranked data and approval voting data, and we now extend it to the study of partially ranked voting data. This involves the computation of a reduced Gröbner basis for the toric ideal of the fixed summary statistic, which forms a Markov basis for the desired sample space. (Received December 31, 2010)

1071-13-145 **Susan E. Morey*** (morey@txstate.edu), Department of Mathematics, Texas State University, 601 University Dr., San Marcos, TX 78666. *Interactions Between Commutative Algebra and Discrete Mathematics.*

There is a natural one-to-one correspondence between square-free monomial ideals generated in degree two and graphs through the construction of edge ideals. This correspondence extends naturally to one between arbitrary square-free monomial ideals and simple hypergraphs, also called clutters or Sperner families, or to facets of a simplicial complex. Using this correspondence, algebraic properties of ideals can be translated into graph theoretic, combinatorial, or combinatorial optimization properties. For example, the Alexandar dual of an edge ideal corresponds to the blocker of the associated clutter, or the transversal hypergraph. This lexicon allows techniques from one of these fields to be used to answer questions from another. This talk will consist of an introduction to recent results in this area and examples of both how graph theoretic and combinatorial techniques are used to prove algebraic results and how algebraic techniques are used to prove results in areas of discrete mathematics. Algebraic properties and invariants of particular interest for this talk include regularity, Cohen-Macaulayness, depth, and associated primes. Discrete properties will include maximal matchings, independent sets, parallelizations, and the Conforti-Cornuéjols conjecture. (Received March 02, 2011)

14 ► Algebraic geometry

1071-14-108 **Edward L Richmond*** (erichmond@math.ubc.ca) and **Arkady Berenstein**. *Littlewood Richardson coefficients for Kac-Moody flag varieties.*

Let G be a complex simple Lie group or Kac-Moody group and P a parabolic subgroup. One of the goals Schubert calculus is to understand the product structure of the cohomology ring $H^*(G/P)$ with respect to its basis of Schubert classes. If G/P is the Grassmannian, then the structure constants corresponding to the Schubert basis are the classical Littlewood-Richardson coefficients which appear in various topics such as enumerative geometry, algebraic combinatorics and representation theory.

In this talk, I will discuss joint work with A. Berenstein in which we give a combinatorial formula for these coefficients in terms of the Cartan matrix corresponding to G. In particular, our formula implies positivity of the "generalized" Littlewood-Richardson coefficients in the case where the corresponding Weyl group of G is a free Coxeter group (i.e. no braid relations). Moreover, this positivity result extends to the torus-equivariant coeffients of $H^*_T(G/P)$ and does not rely on the geometry of the flag variety G/P. (Received February 25, 2011)

1071-14-148 **Oliver Lorscheid*** (olorscheid@ccny.cuny.edu), 160 Convent Avenue, NAC 8/133, Department of Mathematics, New York, NY 10031. *Reductive groups, their Weyl groups and the field with one element.*

In this talk, we review the idea that led Jacques Tits to postulate the existence of a field of "characteristique une" in 1956. A theory of Chevalley groups over this elusive field should explain the analogy between Chevalley groups over finite fields acting on geometric objects and their Weyl groups acting on combinatorical objects.

We explain what a torified variety is and how a reductive group together with a torification recovers both the geometric and the combinatorical viewpoint. We will finish this talk with some remarks about algebraic groups in other approaches than torified varieties towards a geometry over the field with one element. (Received March 02, 2011)

1071-14-175 **Anupam Bhatnagar*** (anupam.nyc@gmail.com), 250 Bedford Park Blvd. West, Bronx, NY 10468. *Canonical Height Zero over Function Fields.*

We give a description of the points of canonical height zero of an algebraic dynamical system defined over the function field of a curve. This is joint work with Lucien Szpiro. (Received March 04, 2011)

15 ► Linear and multilinear algebra; matrix theory

1071-15-122 **Paul A Fuhrmann*** (fuhrmannbgu@gmail.com), Department of Mathematics, Ben-Gurion University of the Negev, Beer Sheva, Israel, and **Uwe Helmke**. *On theorems of Halmos and Roth.* Preliminary report.

This paper, motivated by Halmos [1971], presents an algebraic approach, using polynomial models over an arbitrary field, that yields a functional proof and an extension. This led to an effort to give a simplified, matrix, proof. We use this to explore the connection of Halmos' result with Roth [1952]. This is given by the following. Theorem: Given matrices A, B, C, then the following statements are equivalent:

1. We have the following similarity
$$\begin{pmatrix} A & 0 \\ C & B \end{pmatrix} \simeq \begin{pmatrix} A & 0 \\ 0 & B \end{pmatrix}.$$
2. The subspace $Image \begin{pmatrix} 0 \\ I \end{pmatrix}$ has a complementary $\begin{pmatrix} A & 0 \\ C & B \end{pmatrix}$-invariant subspace.
3. There exists a solution of the following Sylvester equation
$$ZA - BZ = C.$$
4. There exists a matrix commuting with $\begin{pmatrix} A & 0 \\ C & B \end{pmatrix}$ whose kernel is $Image \begin{pmatrix} 0 \\ I \end{pmatrix}$ and whose image is complementary to $Image \begin{pmatrix} 0 \\ I \end{pmatrix}$.

The method presented here generalizes to a class of infinite-dimensional shift operators in a Hardy space. (Received February 28, 2011)

1071-15-174 **Anthony Iarrobino** and **Leila Khatami***, l.khatami@neu.edu. *On Pairs of Commuting Nilpotent Matrices.*

Fix a nilpotent $n \times n$ matrix B over an algebraically closed field k and of Jordan partition P. Consider the centralizer $\mathcal{C}_B$ of B consisting of all $n \times n$ matrices that commute with B and its irreducible subvariety $\mathcal{N}_B$ of nilpotent matrices. There is a Jordan block partition $Q(P)$ of the generic matrix $A \in \mathcal{N}_B$, that is greater than any other Jordan partition occurring for elements of $\mathcal{N}_B$. In this talk we review the basic facts about $Q(P)$ and also discuss a new approach developed by authors. (Received March 04, 2011)

16 ► Associative rings and algebras

1071-16-20 **Sorin Dascalescu**, Str Academiei 14, Sect 1, 010014 Bucharest, Romania, **Miodrag C Iovanov*** (yovanov@gmail.com), Str. Academiei 14, Sect 1, 010014 Bucharest, Romania, and **Constantin Nastasescu**, Str. Academiei 14, Sect 1, 010014 Bucharest, Romania. *Quantum groups with nonzero integral arising from path and incidence (co)algebras.*

A problem of interest in the theory of Hopf algebras is obtaining new quantum groups by defining Hopf algebra structures on path algebras and coalgebras. Similarly, as another class of combinatorial objects, Hopf algebra

structures on incidence (co)algebras of PO-sets are also of interest. We look at a very important class of Hopf algebras, those which have a nonzero integral, which generalize the algebras of functions on compact groups. These are precisely those Hopf algebras which have a representation theoretic property that their categories of co-representations are Frobenius. We work more generally and classify those (co)algebras with this Frobenius property, which embed in quiver coalgebras (pointed) and have a basis of paths. We then classify all Hopf algebra structures arising this way; they prove to have connections to homological algebra and category theory. Using this, we also classify Hopf algebras which are quotient of quiver algebras by monomial ideals. On the other hand, we also give a unifying approach for various finiteness and combinatorial properties for subcoalgebras of path coalgebras, quotients of path algebras and incidence (co)algebras, and give the general connections between these. (Received December 14, 2010)

1071-16-123 **Tobias Pecher*** (pecher@mi.uni-erlangen.de). *Multiplicity-free Super Vector Spaces.*
The action of a reductive group G over $\mathbb{C}$ on a super vector space V is called (G, V) *multiplicity-free (MF)* if the G-module decomposition of the supersymmetric algebra on V contains all irreducible representations of G with multiplicity ≤ 1.

Algebraically, this definition is just the supersymmetric generalization of a MF vector space. These spaces are exactly the *spherical* G-modules, i.e. those representations of G that possess an open orbit of a Borel subgroup. For arbitrary super vector spaces, this criterion fails. What remains true is their characterization in terms of the G-invariant differential operators $\mathbb{PD}(V)^G$: The multiplicity-freeness of V is equivalent to the commutativity of $\mathbb{PD}(V)^G$.

Our investigations of MF super vector spaces are motivated by the relative simple description of these operators in this case. In this talk we indicate the relevance of MF super vector spaces in invariant theory and also present their classification. This list shows a certain duality between symmetric and exterior algebras and thus MF super vector spaces seem to be much more related to spherical varieties than one might expect a priori. The main aim of our talk is to give attention to this phenomenon. (Received February 28, 2011)

17 ► Nonassociative rings and algebras

1071-17-30 **Murray R Bremner*** (bremner@math.usask.ca) and **Mikelis G Bickis**. *Cayley's hyperdeterminant: a combinatorial approach via representation theory.*
In 1841, Cayley introduced a generalization of determinants to multidimensional matrices. These hyperdeterminants are defined to be the polynomial functions of the matrix entries which are invariant under all unimodular changes of variable in the various directions. They can also be characterized as polynomial functions annihilated by certain differential operators. In the simplest case of a 2 by 2 by 2 matrix, Cayley showed that the invariant of lowest degree is a polynomial of degree 4 with 12 terms in 8 variables. We reformulate the definition of hyperdeterminant in terms of the representation theory of the Lie algebra sl(n), and use this to realize the invariant polynomials as the nullspace of a linear map defined on the span of weight zero monomials. Using some elementary combinatorics on three-way contingency tables, we obtain closed formulas for the dimensions of various weight spaces, and use this to give an new proof that Cayley's hyperdeterminant generates all the invariant polynomial functions in this case. (This is joint work with Mik Bickis, a statistician in my Department.) (Received January 10, 2011)

1071-17-54 **Juana Sanchez Ortega*** (jsanchez@agt.cie.uma.es), Dpto. Algebra, Geometria y Topologia, Facultad de Ciencias, Campus de Teatinos, Universidad de Malaga, C.P. 29071 Malaga, Spain. *Finite gradings of Lie algebras.*
This is a joint work with Mercedes Siles Molina.

We show that the algebra $\mathrm{Der}(L)$ of derivations of a strongly nondegenerate Lie algebra L graded by an ordered group G with a finite grading (and satisfying a mild technical condition) inherites the grading from L, i.e. $\mathrm{Der}(L)$, which turns out to be a strongly nondegenerate Lie algebra, is G-graded and has the same support as L. We specialize the result when L is a Lie algebra of the form A^-/Z_A or K/Z_K, for A a semiprime associative algebra, K the Lie algebra of the skew elements of a semiprime associative algebra with involution, and Z_A and Z_K their respective centers. (Received February 07, 2011)

1071-17-66 **Tevian Dray*** (tevian@math.oregonstate.edu), Department of Mathematics, Oregon State University, Corvallis, OR 97331. *The Lie Group Magic Square.* Preliminary report.

Freudenthal and Tits independently showed how to construct a Lie algebra from a pair of division algebras. The resulting magic square includes four of the five exceptional Lie algebras, and does so precisely when one (or both) of the division algebras is the octonions.

The goal of this ongoing project is to provide a direct construction of the Lie groups in the magic square, based on Vinberg's symmetric construction of the corresponding Lie algebras as $su(3, \mathbb{K}_1 \otimes \mathbb{K}_2)$. We are most interested in the "half-split" magic square, when one of the division algebras is split, and which includes some real forms of the exceptional Lie groups, such as $E_{6(-26)}$, which are of particular interest to particle physics.

We first consider a simpler magic square, again of relevance to particle physics, which involves 2×2 matrices over tensor products of division algebras, and find that the corresponding Lie groups can all be represented as $SU(2, \mathbb{K}_1 \otimes \mathbb{K}'_2)$. We then discuss our partial success in interpreting the Freudenthal-Tits magic square as $SU(3, \mathbb{K}_1 \otimes \mathbb{K}'_2)$.

This work is being done in collaboration with John Huerta, Corinne Manogue, and Robert Wilson. (Received February 14, 2011)

1071-17-79 **Young Jo Kwak*** (kwaky@colorado.edu), CO. *Intermediate report of automorphisms of simple Lie algebras G(n) over GF(2).* Preliminary report.

Kaplansky introduced infinite family of simple Lie algebras G(n) over GF(2) in 1982, and hence over all fields of characteristic two. We investigate structure of automorphism group of G(n) over GF(2). Aut(G(4)) is computed. There is a special element in Aut(G(n)) for n>3 which is almost identity. By the graph theoretical arguments of the complete graph Kn (consisting dots, edges, triangles, ...), we see the partial result that "If all edges are fixed, then automorphism must be identity or the special element for n>4." (Received February 18, 2011)

1071-17-134 **Alexander A. Mikhalev*** (aamikhalev@mail.ru), Faculty of Mechanics and Mathematics, Moscow State University, Moscow, 119991, Russia. *Primitive and almost primitive elements of free non-associative algebras.*

A variety of linear algebras over a field is Schreier if any subalgebra of a free algebra of this variety is free in the same variety of algebras. A system of elements of a free algebra is primitive if it is a subset of some set of free generators of this free algebra. We consider free Lie algebras and superalgebras, free Lie p-algebras and p-superalgebras, free non-associative algebras, free commutative non-associative algebras, and free anti-commutative non-associative algebras. Algorithms to recognize primitive systems of elements and algorithms to construct complements of primitive systems of elements with respect to free generating sets are constructed and implemented. An almost primitive element of a free algebra F is an element which is not primitive in F, but which is primitive in any proper subalgebra of F containing it. A series of almost primitive elements of free algebras of Schreier varieties is constructed. We obtain criteria for a homogeneous element to be almost primitive. This talk is based on joint works with C.Champagnier, A.A.Chepovskii, A.V.Klimakov, A.V.Mikhalev, U.U.Umirbaev, J.-T.Yu, and A.A.Zolotykh. (Received March 01, 2011)

1071-17-165 **Samuel H Chamberlin*** (samcham@math.ucr.edu), University of California at Riverside, 900 University Ave., Department of Mathematics Surge 202, Riverside, CA 92521. *Integral forms and integral bases for the universal enveloping algebras of map algebras.*

We exhibit integral forms, and explicit integral bases for these integral forms, for the universal enveloping algebras of the map algebras. We also give explicit straightening identities in these universal enveloping algebras, which allow one to write certain monomials in Poincaré-Birkhoff-Witt order. We give applications of these identities to the representation theory of map algebras. (Received March 03, 2011)

20 ► Group theory and generalizations

1071-20-02 **Danny Calegari*** (dannyc@its.caltech.edu), Department of Mathematics, California Institute of Technology, Pasadena, CA 91125. *Stable commutator length in free groups.*

Stable commutator length (scl) answers the question: "what is the simplest surface in a given space with prescribed boundary?" where "simplest" is interpreted in topological terms. This topological definition is complemented by several equivalent definitions - in group theory, as a measure of non-commutativity of a group; and in linear programming, as the solution of a certain linear optimization problem. On the topological side, scl is concerned with questions such as computing the genus of a knot, or finding the simplest 4-manifold that bounds a given 3-manifold. On the linear programming side, scl is measured in terms of certain functions called

quasimorphisms, which arise from hyperbolic geometry (negative curvature) and symplectic geometry (causal structures).

I will discuss how scl in free groups is connected to such diverse phenomena as the existence of closed surface subgroups in graphs of groups, rigidity and discreteness of symplectic representations, phase locking for nonlinear oscillators, and the theory of multi-dimensional continued fractions and Klein polyhedra. (Received January 02, 2011)

1071-20-19 **Ellen M Ziliak***, eziliak@ben.edu, and **Alexander Hulpke**. *Rewriting using a Stalling Subgroup Graph.*

A Stalling Graph for a subgroup N is the directed graph obtained from the disjoint union of the paths in by identifying the root vertices. If we consider a finitely presented group $G \cong F/N$, then G can be thought of as a quotient group. Where G is a quotient of F a free group, and N is the normal closure of the subgroup generated by the relators given for G, we can construct a Stalling Subgroup Graph for N. It turns out that this graph includes all of the necessary information contained in the Cayley Graph for G that is used to rewrite words in F as a product of conjugates of the relators given for G. In this talk use the Stalling Subgroup Graph for N to give a more efficient algorithm to rewrite words in a finitely presented group as a product of conjugates of relators. As a practical application to this algorithm one can use it to do arithmetic in group extensions assuming the 2-cocycles are given. (Received December 09, 2010)

1071-20-38 **Tara C Davis*** (tara.c.davis@vanderbilt.edu), 1326 Stevenson Center, Department of Mathematics, Vanderbilt University, Nashville, TN 37240, and **Alexander Yu. Olshanskii**. *Distortion in Wreath Products of Cyclic Groups.*

I will discuss some effects of subgroup distortion in the wreath products A wr Z, where A is finitely generated abelian. The effects of distortion in these groups is similar to that in free metabelian groups. One result is that every finitely generated subgroup of A wr Z has distortion function bounded above by some polynomial. I will also mention a formula for the length of elements in arbitrary wreath product H wr G, and how it applies to distortion. (Received January 26, 2011)

1071-20-39 **Christopher H. Cashen*** (cashen@math.utah.edu). *Virtually Geometric Multiwords.*

A multiword in a free group F is geometric if it can be realized as an embedded multicurve on the surface of a handlebody with fundamental group F. It is virtually geometric if it becomes geometric upon passing to a finite index subgroup. I will show that virtually geometric multiwords are exactly those that are built from geometric pieces. (Received January 26, 2011)

1071-20-45 **Bernhard Amberg*** (amberg@mathematik.uni-mainz.de), Institut fuer Mathematik, Universitaet Mainz, D-55128 Mainz, Germany. *Groups covered by dihedral groups.*

It is well-known that two distinct involutions in any group generate a dihedral group. A group is locally dihedral if it has a local system of dihedral subgroups. Obviously periodic locally dihedral groups are locally finite and every finite subgroup is contained in a (finite) dihedral subgroup.

It is easy to see that every locally finite group which is 'saturated' by dihedral subgroups in the latter sense is locally dihedral. Shlyopkin and Rubashkin (2005) have shown that this also holds for some further classes of periodic groups G, for instance when the elements of G have bounded period or when each pair of conjugate elements of prime order generates a finite group.

In joint work with L. Kazarin we show that in fact all periodic groups in which every finite subgroup is contained in a dihedral subgroup are locally dihedral.

The proof of this theorem depends heavily on the following solubility criterion for factorized groups, which is of independent interest.

Theorem. If the group $G = AB$ is the product $G = AB$ of two periodic locally dihedral subgroups A and B, then G is soluble. (Received February 05, 2011)

1071-20-56 **Danny Calegari** and **Alden Walker*** (awalker@caltech.edu), Dept of Math M/C 253-37, 1200 E California Blvd, Pasadena, CA 91106. *Isometric endomorphisms of free groups.*

An arbitrary homomorphism between groups is nonincreasing for stable commutator length, and there are infinitely many (injective) homomorphisms between free groups which strictly decrease the stable commutator length of some elements. However, we show in this paper that a random homomorphism between free groups is almost surely an isometry for stable commutator length for every element; in particular, the unit ball in the scl norm of a free group admits an enormous number of exotic isometries.

Using similar methods, we show that a random fatgraph in a free group is extremal (i.e. is an absolute minimizer for relative Gromov norm) for its boundary; this implies, for instance, that a random element of a free group with commutator length at most n has commutator length exactly n and stable commutator length exactly n-1/2. Our methods also let us construct explicit (and computable) quasimorphisms which certify these facts. (Received February 08, 2011)

1071-20-73 **Jon McCammond*** (jon.mccammond@math.ucsb.edu), Department of Mathematics, 3080, Santa Barbara, CA 93106. *Factoring euclidean isometries.*

Every good geometry book proves that each isometry of euclidean n-space is a product of at most $n+1$ reflections and several more-advanced sources include Scherk's theorem which identifies the minimal length of such a reflection factorization from the basic geometric attributes of the isometry under consideration. The structure of the full set of minimal length reflection factorizations, on the other hand, does not appear to have been given an elementary treatment in the literature even though the proof only requires basic geometric tools. In this talk I construct, for each isometry, an explicit combinatorial model encoding all of its minimal length reflection factorizations. The model is largely independent of the isometry chosen in that it only depends on whether or not some point is fixed and the dimension of the space of directions that points are moved. Joint work with Noel Brady. (Received February 15, 2011)

1071-20-80 **Volker Diekert*** (diekert@fmi.uni-stuttgart.de), Universitaetsstrasse 38, 70569 Stuttgart, Germany. *Solving word problems in groups by data compression.*

It is well-known that data compression might be essential to solve word problems in groups efficiently. For example, Schleimer showed that the automorphism group of a free group has a WP in PTIME using straight-line programs. Much higher compression rates can be obtained by power circuits. Power circuits were introduced by Myasnikov, Ushakov and Won and they showed that the WP of the Baumslag group $G_{(1,2)}$ with one defining relation $a^{a^b} = a^2$ is in PTIME. This result has been surprising, since the Dehn function of $G_{(1,2)}$ is non-elementary by a result of Gersten; and $G_{(1,2)}$ was believed to be among the hardest one-relator groups w.r.t. the complexity of the word problem.

In my lecture I will report on some new results in this area. (Received February 20, 2011)

1071-20-86 **sameh fathy el hadidi*** (sameh2002@yahoo.com), 10 talat Basha st.sanstefano,Alexandria,Egypt, alexandria, Egypt, and **Nahed gamal el sharkawy** (sameh2002@yahoo.com), 18 el krom st. Mohandsien cairo Egypt, cairo, Egypt. *Parametric Representations of Finite Groups with two Independent Generators with one Being of Given Order.*

In this paper, we study the general products of two finite cyclic groups one being of order 4 or 6 but the order of the other generator is m, where $2 < m < 20$. The general products obtained were described in terms of numerical parameters. All our results were checked by a computer program (Mat Lap Program). (Received February 22, 2011)

1071-20-92 **sameh fathy elhadidi*** (sameh2002@yahoo.com), 10 talat basha st sanstefano,alexandria,egypt, alexandria, Egypt, and **nahed gamal elsharkawy** (sameh2002@yahoo.com), 18 el krom st.mohandesein,cairo egypt, cairo, Egypt. *Fourier Series Associated With An Almost Periodic Function On Groups To Banach Space.*

L. Amero studied almost periodic functions on reals to Banach spaces, J. V. Neumann studied it in the case of almost periodic functions on groups to reals and so we want to extend this study by finding Fourier series associated with such functions on groups to Banach spaces. (Received February 23, 2011)

1071-20-112 **James W. Cannon*** (cannon@math.byu.edu), BYU Math Dept — 290 TMCB, Provo, UT 84602. *The Planar Subdivision Rule in Geometric Group Theory and Dynamical Systems.* Preliminary report.

We consider the planar subdivision rule as a notion that unifies interesting portions of the study of hyperbolic knot groups, Kleinian groups, rational maps, and geometric 3-manifolds.

We review existence theorems of Cannon-Floyd-Perry and Bonk-Meyer and recent applications, with particular attention to the wonderful work of Daniel Meyer and Brian Rushton, as well as some of our own results. (Received February 25, 2011)

1071-20-117 **Delaram Kahrobaei**, NY, **Charalambos Koupparis*** (ckoupparis@gc.cuny.edu), NY , and **Vladimir Shpilrain**, NY. *Public Key Exchange Using Matrices Over Group Rings.*

We propose to look at the Diffie-Hellman key exchange protocol using matrices over group rings. In order to determine the validity and security of this scheme the Decision Diffie-Hellman (DDH) and Computational Diffie-Hellman (CDH) problems will be addressed. We will be working with matrices defined over group rings $\mathbb{Z}_m[S_n]$, and specifically $\mathbb{Z}_2[S_5]$. (Received February 27, 2011)

1071-20-136 **Lucas Sabalka*** (sabalka@math.binghamton.edu) and **Dmytro Savchuk** (dsavchuk@math.binghamton.edu). *On the Geometry of a Proposed Curve Complex Analogue for $Out(F_n)$.*

The group $Out(F_n)$ of outer automorphisms of the free group has been an object of active study for many years, yet its geometry is not well understood. Recently, effort has been focused on finding a hyperbolic complex on which $Out(F_n)$ acts, in analogy with the curve complex for the mapping class group. In this talk on joint research with Dima Savchuk, we'll discuss some results about the geometry of edge splitting graph, or equivalently the separating sphere graph, a space on which $Out(F_n)$ acts and a proposed candidate for a curve complex analogue. We give a characterization of geodesic paths in this graph, and use our characterization to find lower bounds on distances between vertices. Our distance calculations allow us to find quasiflats of arbitrary dimension. Thus, this graph is not hyperbolic and has infinite asymptotic dimension. (Received March 01, 2011)

1071-20-160 **Anthony E Clement*** (aclement@brooklyn.cuny.edu). *An algorithm that decides conjugacy in a certain generalized free product.*

We consider a certain cyclically pinched generalized free product and show through a constructive process, that it is residually free. We devise an explicit algorithm to solve the conjugacy problem for this cyclically pinched generalized free product. (Received March 03, 2011)

1071-20-215 **Margaret H Dean*** (mdean@bmcc.cuny.edu), **Marcos Zyman** and **Marianna Bonanome**. *IA-automorphisms of groups with constant upper central series.*

Let G be any group satisfying the property that $Z_2 = Z_1$ in the upper central series. It will be shown that the subgroup of $Aut(G)$ generated by the central automorphisms together with the inner automorphisms is a direct product of these two subgroups. If $Z_1 \leq G'$, we offer necessary and sufficient conditions for $IA(G)$ to equal the direct product of the inner automorphisms with the central automorphisms. These conditions can be generalized to the case where $Z_n = Z_{n+1}$ in the upper central series for some $n \geq 1$. We apply our results to certain finitely generated center-by-metabelian groups. (Received March 06, 2011)

1071-20-224 **Matthias Neumann-Brosig*** (m.neumann-brosig@tu-bs.de), Institut Computational Mathematics, TU Braunschweig, 38106 Braunschweig, Germany, and **Gerhard Rosenberger**. *Homological finiteness conditions of hyperbolic groups.*

Hyperbolic groups have been studied in various fields in mathematics. They appear in contexts as diverse as geometric group theory, function theory (as Fuchsian groups) and algebraic topology (as fundamental groups of compact hyperbolic surfaces). Hyperbolic groups possess geometrical properties well suited for the study of homological finiteness conditions. In this talk we will prove some of these results via free resolutions obtained from the Rips-complex. cf: Groups - Complexity - Cryptology 2 (2010), deGruyter, p. 203-212. (Received March 08, 2011)

1071-20-229 **Matthew B. Day*** (mattday@caltech.edu), Mathematics 253-37, Caltech, Pasadena, CA 91125. *The connectivity threshold and automorphisms of random right-angled Artin groups.*

We consider the outer automorphism group $\mathrm{Out}(A_\Gamma)$ of a right-angled Artin group defined by a random graph Γ in the Erdős–Rényi model. We show that as the number of vertices gets large, the range of edge probabilities for which $\mathrm{Out}(A_\Gamma)$ is finite is essentially the same as the range of edge probabilities for which both Γ and the complement graph of Γ are connected. This sharpens a result of Charney–Farber. (Received March 07, 2011)

1071-20-249 **Margaret H Dean**, **Gretchen Ostheimer** and **Marcos Zyman*** (mzyman@bmcc.cuny.edu), BMCC Department of Mathematics, 199 Chambers St., New York, NY 10007. *Automorphisms of wreath products.*

Let W be the wreath product of a finitely generated free abelian group by another. We discuss some results pertaining to the structure of $Aut(W)$ and $IA(W)$. Here, $Aut(W)$ denotes the automorphism group of W and $IA(W)$ is the subgroup of $Aut(W)$ consisting of those automorphisms that induce the identity on W abelianized. (Received March 07, 2011)

1071-20-254 **Robert M Beals*** (beals@idaccr.org), 805 Bunn Drive, Princeton, NJ 08540. *Optimal black-box algorithms for the symmetric groups.*

We give an algorithm to determine whether a given black-box group is isomorphic to the symmetric group S_n. The parameter n is unknown, although it is bounded by the inequality $n! \leq 2^\ell$, where ℓ is the number of bits in the encoding of an element. This algorithm requires that each group element be represented by a unique string. The complexity, if the group is given by r generators, is $O(rn)$ operations to prove that the group is S_n, and $O(r\ell/\log \ell)$ group operations if the group is not proved to be S_n. If the group is isomorphic to S_n, then the algorithm succeeds with probability $1 - \exp(-rn^{1-o(1)})$.

Our second main result is that both our algorithm and a related algorithm of Beals, Leedham-Green, Neimeyer and Praeger are optimal in their respective computational models. Our lower bound actually applies to all finite groups G: a one-sided Monte Carlo algorithm to determine that a given black-box group is isomorphic to G requires $\Omega(\log |G|/\log\log |G|)$ operations if group elements are represented by unique strings, and $\Omega(\log |G|)$ operations otherwise. (Received March 07, 2011)

1071-20-278 **Laszlo Babai** (laci@cs.uchicago.edu), **Paolo Codenotti*** (paoloc@cs.uchicago.edu) and **Youming Qiao** (jimmyqiao86@gmail.com). *On the Group Isomorphism problem.* Preliminary report.

The isomorphism problem for groups given by their multiplication tables has long been known to be solvable in time $n^{\log n}$, where n is the order of the group. The decades-old quest for a polynomial-time algorithm has focused on the very difficult case of class-2 nilpotent groups, with little success so far; J. B. Wilson has recently obtained significant new invariants for this class (J. Algebra, 2009). We consider the opposite end of the spectrum, groups without abelian normal subgroups. We work towards a polynomial time isomorphism test for this class.

We use the BB-filtration (Babai and Beals, Bath, 1999) to link our problem to permutational isomorphism of permutation groups and equivalence of (not necessarily linear) codes. (The BB-filtration was orginially introduced as a framework for computation in matrix groups.) Our algorithm for code equivalence is obtained by generalizing Luks's algorithm for hypergraph isomorphism (FOCS, 1999).

This work builds on a previous joint paper with Joshua A. Grochow (SODA, 2011). (Received March 08, 2011)

1071-20-279 **Murray Elder**, **Gillian Z. Elston** and **Gretchen Ostheimer*** (Gretchen.Ostheimer@hofstra.edu). *Groups with Logspace Normal Form.*

One natural measure of the complexity of a finitely generated group is the computational complexity of a normal form function for the group, as such a normal form enables us to perform all three basic group operations – equality testing, multiplication and inversion. Many researchers have attempted (and continue to attempt) to categorize groups according to the time complexity, the space complexity and other language-theoretic measures of complexity of these three basic operations. In this talk, we present work-in-progress toward an answer to the following question: in what kinds of groups can these three basic operations be performed with very limited memory space? More specifically, what kinds of groups have a normal form function that can be computed by a Turing machine in which the size of the work tape is bounded by the logarithm of the size of the input? (Received March 08, 2011)

22 ► Topological groups, Lie groups

1071-22-58 **Matthew Stover*** (stoverm@umich.edu), Department of Mathematics, University of Michigan, 530 Church Street, Ann Arbor, MI 48109. *Geometry, arithmetic, and group theory.*

Properties of the modular group SL(2; Z) motivate several fundamental questions in geometric group theory. It is also the most well-known arithmetic lattice in a semisimple Lie group. I will describe how some of the arithmetic, geometric, and topological properties of the modular group and modular surface persist, in a very precise way, for analogous lattices in other semisimple groups and their corresponding quotient spaces. Part of this is joint work with Ted Chinburg. (Received February 10, 2011)

1071-22-74 **Markus Hunziker*** (Markus_Hunziker@baylor.edu), Department of Mathematics, Baylor University, One Bear Place #97328, Waco, TX 76798-7328, and **Mark R. Sepanski**. *Abelian ideals of a Borel subalgebra, generalized Young diagrams, and subsets of simple roots.* Preliminary report.

Let $\mathfrak{g}$ be a complex simple Lie algebra and $\mathfrak{b}$ a Borel subalgebra of $\mathfrak{g}$. Recently, D. Panyushev noticed that the number of abelian ideals of $\mathfrak{b}$ with k generators is equal to the number of subdiagrams of the Dynkin diagram of $\mathfrak{g}$ with k connected components. In this talk, we will use a generalization of Young diagrams to give bijective proofs of these equalities when $\mathfrak{g}$ is of classical tpe. We also show the non-existence of bijections that would satisfy certain nice properties across all types. (Received February 16, 2011)

1071-22-144 **Paolo Casati*** (paolo.casati@unimib.it), Via Cozzi 53, I-20125 Milano, Italy. *Irreducible SL_{n+1}–Representations remain Indecomposable restricted to some Abelian Subalgebras.*

The aim of this talk is to show that any finite dimensional irreducible representation of a complex simple Lie algebra of type A remains indecomposable if restricted to some abelian subalgebras of dimension [1] (Theorem 3.9). Such abelian subalgebra $\mathfrak{a}$ can be constructed as follows.

Let $\mathfrak{g}$ be the complex simple Lie algebra A_n, $\mathfrak{h} \subset \mathfrak{g}$ its Cartan subalgebra and $\Delta = \Delta(\mathfrak{g}, \mathfrak{h})$ the corresponding set of roots. Further for any $\alpha \in \Delta$ let X_α be a basis of $\mathfrak{g}_\alpha = \{X \in \mathfrak{g} |\ [H, X] = \alpha(H)X\ \forall H \in \mathfrak{h}\}$, $\Pi = \{\alpha_1, \ldots, \alpha_n\}$ a set of simple roots in Δ and set $Y_{\alpha_i} = X_{-\alpha_i}$, then $\mathfrak{a}$ is the abelian subalgebra of $\mathfrak{g}$ spanned by the vectors $\{Y_{\alpha_{2i+1}}\}$ $(i = 0, \ldots, \left[\frac{n}{2}\right])$ and $\{X_{\alpha_{2j}}\}$ $(j = 1, \ldots, \left[\frac{n}{2}\right])$, where $[x]$ denotes the integer part of x.

[1] P. Casati *Irreducible SL_{n+1}–Representations remain Indecomposable restricted to some Abelian Subalgebras* Journal of Lie Theory Volume **20** (2010) 393–407 (Received March 02, 2011)

1071-22-225 **Gautam Chinta*** (chinta@sci.ccny.cuny.edu), CCNY, Dept. of Math, NAC 8133, New York, NY 10031, and **Omer Offen**. *Metaplectic Whittaker functions.*

Whittaker functions are higher-dimensional generalizations of classical Bessel functions that arise naturally as solutions to rather independent problems in number theory and in physics. We establish a formula for p-adic Whittaker functions on the n-fold metaplectic cover of GL(n), generalizing the formula of Shintani and Casselman-Shalika. (Received March 07, 2011)

1071-22-274 **Susana A. Salamanca-Riba*** (ssalaman@nmsu.edu), **Pantano Alessandra** and **Annegret Paul**. *Some unitary representations of the metaplectic group.* Preliminary report.

In this lecture we will present a construction of unitary representations of Mp(2n) and show they parametrize a subset of the unitary dual with some regularity condition of the infinitesimal character and give an idea of similar constructions for other split groups. (Received March 08, 2011)

30 ► Functions of a complex variable

1071-30-70 **Michael T. Lacey** (Lacey@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332, **Prause Istvan** (istvan.prause@helsinki.fi), Department of Mathematics, P.O. Box 68 (Gustaf Hallstromin katu 2b), University of Helsinki, FI-00014 Helsinki, Finland, **Tolsa Xavier** (xtolsa@mat.uab.cat), Departament de Matematiques, Universitat Autonoma de Barcelona, 08193 Bellaterra, Barcelona, Spain, **Sawyer T. Eric** (sawyer@mcmaster.ca), Dept. of Mathematics & Statistics, McMaster University, 1280 Main Street West, Hamilton, Ontario L8S 4K1, Canada, and **Uriarte-Tuero Ignacio*** (ignacio@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824. *Two conjectures of Astala on distortion under planar quasiconformal mappings and related removability problems.*

In his celebrated paper on area distortion under planar quasiconformal mappings (Acta 1994), Astala proved that if E is a compact set of Hausdorff dimension d and f is K-quasiconformal, then fE has Hausdorff dimension at most $d' = \frac{2Kd}{2+(K-1)d}$, and that this result is sharp. He conjectured (Question 4.4) that if the Hausdorff measure $\mathcal{H}^d(E) = 0$, then $\mathcal{H}^{d'}(fE) = 0$.

UT showed that Astala's conjecture is sharp in the class of all Hausdorff gauge functions (IMRN, 2008).

Lacey, Sawyer and UT jointly proved completely Astala's conjecture in all dimensions (Acta, 2010). The proof uses Astala's 1994 approach, geometric measure theory, and new weighted norm inequalities for Calderón-Zygmund singular integral operators which cannot be deduced from the classical Muckenhoupt A_p theory.

These results are related to removability problems for various classes of quasiregular maps. I will mention sharp removability results for bounded K-quasiregular maps (i.e. the quasiconformal analogue of the classical Painleve problem) recently obtained jointly by Tolsa and UT.

I will further mention recent results related to another conjecture of Astala on Hausdorff dimension of quasicircles obtained jointly by Prause, Tolsa and UT. (Received February 14, 2011)

1071-30-115 **Jan Cristina**, **Tadeusz Iwaniec**, **Ngin-Tee Koh**, **Leonid V. Kovalev*** (lvkovale@syr.edu) and **Jani Onninen**. *Energy minimizing planar maps.*

Two generic k-connected domains in the plane are not conformally equivalent unless $k = 1$. In other words, they do not admit a diffeomorphic solution of the Cauchy-Riemann system. We attempt to solve the Cauchy-Riemann system in the least squares sense; that is, to minimize the L^2 norm of the $\bar{\partial}$-derivative among all diffeomorphisms. Although this problem is equivalent to the minimization of the Dirichlet energy, the Laplace equation is not always available. The existence of energy minimizing diffeomorphisms is not guaranteed, but they do exist under more general hypotheses than conformal maps. If the class of diffeomorphisms is enlarged to ensure the existence of minimizers for any pair of domains, new surprises occur: the minimizers are locally Lipschitz, but are not necessarily differentiable. (Received February 26, 2011)

1071-30-167 **Mario Bonk*** (mbonk@math.ucla.edu). *Quasisymmetric uniformization and rigidity.*

Uniformization by quasisymmetric maps and rigidity phenomena for such maps are linked to questions in geometric group theory and and in complex dynamics. In my talk I will give a survey on some recent developments. (Received March 03, 2011)

1071-30-243 **Hrant Hakobyan*** (hakobyan@math.ksu.edu), 138 Cardwell Hall, Department of Mathematics, Manhattan, KS 66506-2602. *Modulus estimates in slit carpets and Menger curves.* Preliminary report.

We obtain upper bounds for curve families in "slit carpets" first studied by Merenkov. One application of these bounds is that we obtain many new examples of quasisymmetrically co-Hopfian spaces (in particular of spaces homeomorphic to the Menger curve). Another application is a sufficient condition for the failure of Poincare inequality for non self-similar slit carpets. (Received March 07, 2011)

1071-30-250 **Marina Borovikova*** (mborovikova@fullerton.edu), mborovikova@fullerton.edu, and **Zair Ibragimov**. *The third symmetric product of lines and circles.*

We discuss the notion of symmetric product of metric spaces. This notion was introduced by Polish mathematicians K. Borsuk and S. Ulam in 1930's and has since been studied by many authors, mostly in topology. Recent studies have shown that this notion is also useful in Analysis. The n-th symmetric product of a metric space X is the set of subsets of X of cardinality less than or equal to n, equipped with the Hausdorff metric. In this talk we discuss some analytic and geometric properties of the third symmetric product of lines and circles. (Received March 08, 2011)

1071-30-264 **Abdelkrim Brania*** (abrania@morehouse.edu), 830 Westview Drive S.W., D.H Suite 303, Atlanta, GA 30314. *Distortion property of a class of embeddings.*

We review the geometric characterization of the class of asymptotically symmetric embeddings in the plane and then we discuss the distortion and boundedness properties of these embeddings in general settings. (Received March 08, 2011)

32 ► Several complex variables and analytic spaces

1071-32-226 **Sevdiyor Akramovich Imomkulov*** (sevdi@rambler.ru), 45, Ibn Sino street, Navoi, Navoi 706800, Uzbekistan, and **Zafar Shavkatovich Ibragimov** (z.ibragim@gmail.com), 14, H.Olimjan street, Urgench, Khorezm 220100, Uzbekistan. *Theorem of uniqueness for quasianalytic functions of several variables in thew sense of Gonchar.*

Abstract:

We proved the theorem of uniqueness for the class of quasianalytic functions of several variables in the sense of Gonchar, i.e. every nonpluripolar set is uniqueness set of class of quasianalytic functions of Gonchar. (Received March 07, 2011)

1071-32-259 **Bakhrom Ismoilovich Abdullaev*** (abahrom1968@mail.ru), 14, H.Olimjan street, Urgench, Khorezm 220100, Uzbekistan, and **Rasul Ahmedovich Sharipov** (sharipovr80@mail.ru), 14, H.Olimjan street, Urgench, Khorezm 220100, Uzbekistan. *K - Harmonic functions.*

We discuss properties of K - harmonic functions. A function $U(z)$, $z \in D \subset \mathbf{C^n}$ called K-harmonic in the domain D if

$$(dd^cU)^k \Lambda (dd^c |z|^2)^{n-k} = 0, \;\; z \in D, \;\; 1 < k < n.$$

(Received March 09, 2011)

1071-32-260 **Ruzimbay Masharipovich Madrakhimov*** (mruzimbay@mail.ru), 14, H.Olimjan street, Urgench, Khorezm 220100, Uzbekistan. *Criterion of pluriharmonicity of harmonic functions.*

We proved the creterion of pluriharmonicity of harmonic functions in terms of cut-functions. Let $u(z) \in C^2(D)$, $D \subset \mathbb{C}^n$ be a function such that $\Delta u = 0$ in a neighborhood of some fixed point $z^0 \in D$ and that

$$\sum_{i,j=1}^{n} \left(z_i - z_i^0\right) \left(\bar{z}_j - \bar{z}_j^0\right) (D_i \bar{D}_j u)(z) \geq 0.$$

Then $u(z)$ pluriharmonic in D. (Received March 09, 2011)

33 ► Special functions

1071-33-18 **Gopala Krishna Srinivasan*** (gopal@math.iitb.ac.in), Department of Mathematics, Indian Institute of Technology Bombay, Powai, Mumbai, 400019, India. *A new approach to the integrals of Barnes, Mellin and Hecke.*

In this paper we provide a unified approach to a family of integrals of the Barnes - Mellin type involving products of gamma functions along vertical lines in the plane, using the theory of Fourier integral operators. Interesting features arise in many of the cases which call for the application of pull-backs of distributions via smooth submersive maps defined by Hörmander. We derive by this method the integrals of Hecke and Sonine relating to various types of Bessel's functions which have found applications in analytic and algebraic number theory. (Received January 30, 2011)

34 ► Ordinary differential equations

1071-34-180 **Stephen Robinson*** (sbr@wfu.edu) and **Pavel Drabek**. *Continua of local minimizers in a non smooth model of phase transitions.*

We study critical points of the functional

$$J_\epsilon(u) := \frac{\epsilon^p}{p} \int_0^1 |u_x|^p dx + \int_0^1 F(u) dx, u \in W^{1,p}[0,1],$$

where $F : \Re \to \Re$ is assumed to be a double-well potential. This functional represents the total free energy in models of phase transition and allows for the study of interesting phenomena such as *slow dynamics*. In particular we consider a non-classical choice for F has the shape, but lacks the smoothness, of $F(u) = |1 - u^2|^2$. The lack of smoothness in F at ± 1 leads to the existence of multiple continua of critical points that are not present in the classical case. We prove that the interior of these continua are local minima. The energy of these local minimizers is strictly greater than the global minimum of J_ϵ. In particular, the existence of these continua leads to an alternative explanation for the slow dynamics observed in phase transition models. (Received March 04, 2011)

1071-34-198 **Adolfo J. Rumbos*** (arumbos@pomona.edu), Department of Mathematics, Pomona College, 610 N. College Avenue, Claremont, CA 91711, and **David A. Bliss**. *Periodic Boundary Value Problems and the Dancer–Fučík Spectrum Under Conditions of Resonance.* Preliminary report.

We prove the existence of solutions to the nonlinear 2π-periodic problem

$$u''(x) + \mu u^+(x) - \nu u^-(x) + g(x, u(x)) = f(x), \quad x \in (0, 2\pi),$$
$$u(0) - u(2\pi) = 0, \;\; u'(0) - u'(2\pi) = 0,$$

where the point (μ, ν) lies in the Dancer–Fučík spectrum, with

$$0 < \frac{4}{9}\mu \leqslant \nu < \mu < (m+1)^2,$$

for some natural number m, and the nonlinearity $g(x,\xi)$ is bounded with primitive, $G(x,\xi)$, satisfying a generalized Landesman-Lazer type condition introduced by Tomiczek in 2005. We use variational methods based on the generalization of the Saddle Point Theorem of Rabinowitz. (Received March 05, 2011)

35 ► Partial differential equations

1071-35-6 **Mimi Dai*** (mdai@slugmail.ucsc.edu), 828 Koshland Way, Santa Cruz, CA 95064, and **Jie Qing** and **Maria Schonbek**. *Norm inflation for incompressible magneto-hydrodynamic system in $\dot{B}_{\infty}^{-1,\infty}$.*

Based on the construction of Bourgain and Pavlović for Navier-Stokes equations, we demonstrate that the solutions to the Cauchy problem for the three dimensional incompressible magneto-hydrodynamics (MHD) system can develop different types of norm inflation in $\dot{B}_{\infty}^{-1,\infty}$. Particularly the magnetic field can develop norm inflation in short time even when the velocity remains small and vice verse. Another interesting case is that, even with zero initial velocity, the velocity field can develop norm inflation in short time. We constructed different initial data to obtain these results using plane waves. (Received September 05, 2010)

1071-35-10 **Qiang Du*** (qdu@math.psu.edu), Department of Mathematics, Penn State University, University Park, PA 16802. *Stochastic models for complex fluid structure interactions.*

In this talk, we present a couple of models that incorporate fluctuation effects in the study of complex fluid structure interactions within the diffuse interface framework. We discuss their mathematical properties and examine issues that may be important to numerical simulations. (Received November 01, 2010)

1071-35-21 **Loc H Nguyen*** (loc@math.utah.edu), 155S 1400E Rm 233, Salt Lake City, UT 84112, and **Klaus Schmitt** (schmitt@math.utah.edu), 155S 1400E Rm 233, Salt Lake City, UT 84112. *Applications of Sub-supersolution theorems to singular nonlinear elliptic problems.*

The motivation for the results presented here are several recent papers on singular boundary value problems for semilinear elliptic equations with convection terms. We present extensions which cover singular nonlinear equations (mainly equations involving the $p-$Laplacian) containing convection terms. The results obtained are proved using sub- and supersolution theorems (motivated by the sub- supersolution theorems of Le and the second author) and the construction of a well-ordered pair of such using a principal eigenfunction of the $p-$Laplacian. (Received December 16, 2010)

1071-35-24 **Leonid Andreevich Muravey*** (L_Muravey@mail.ru), Muravey, Leonid, Andreevich, Moscow, 119333, Russia, **Ismail Gabulla Ogly Ismailov** (pm@mati.ru), Ismailov, Ismail, Gabulla Ogly, Moscow, Russia, and **El'chin Teyubovich Eyniev** (pm@mati.ru), Eyniev, El'chin, Teyubovich, Moscow, 129346, Russia. *Some issues of optimization theory on solutions of operator equations.*

The mathematical setting of many problems of search for the optimum form or properties of materials in constructions is reduced to the problem of optimal control of the processes occurring in continuous media. In this connection the minimized functional (or the goal one) is determined as a result of solving the boundary problems for the partial differential equations called as a state equation. The natural generalization of such kind problems are the optimization problems in the presence of connections in the form of the operator equations. This work deals with the investigation of decidability of such problems and with the determination of the necessary conditions, characterizing their solution. For example, the notion of solving the equation with the non-restricted coefficients, using which the problem of control of the elliptical equation setting region, is reduced to the problem of control of lower coefficients. The optimality necessary condition in the form of the Pontryagin maximum with further application to the problem of control of lower coefficients, and hence, to the problems of control of the equation setting region, is being proved. (Received December 22, 2010)

1071-35-28 **John W Neuberger*** (jwn@unt.edu). *Using a Lie generator to determine if a semidynamical system is local or global.*

Suppose that X is a complete separable metric space and T is either a global or local (in time) jointly continuous semidynamical system on X. Denote by $C(X)$ the space of all bounded continuous real-valued functions on X and

$$A = \{(f,g) \in C(X)^2 : g(x) = \lim_{t \to 0+} \frac{1}{t}(f(T(t)x) - f(x)), x \in X\}.$$

Theorem: T is global if and only if A has no positive eigenvalue. Possible applications to concrete systems such as Navier-Stokes are discussed. (Received January 01, 2011)

1071-35-36 **Pao-Liu Chow*** (plchow@math.wayne.edu), Department of Mathematics, Wayne State University, 656 W Kirby St., Detroit, MI 48202. *Unbounded Solutions of Some Semilinear Stochastic PDEs.*

The talk is concerned with some recent results on the explosive solutions for a class of nonlinear stochastic parabolic and hyperbolic equations. In the deterministic case, the blow-up of solutions in finite time for nonlinear PDEs has been studied extensively. It is of theoretical and applied interest to examine the effect of random perturbation on the existence of explosive solutions. For the parabolic case, such as stochastic reaction-diffusion equations, we will show that under some sufficient conditions on the initial data, the nonlinear terms and the multiplicative noise, there exist positive solutions that blow up in finite time in the mean L^p-sense for any p greater or equal to one. Two examples are given to show the possibility of blow-up due to the nonlinear term and the noise term respectively. In the case of stochastic wave equations, we obtain some sufficient conditions for the existence of explosive solutions in the mean-L^2 norm. In contrast with the parabolic case, the proof is based on a stochastic energy method. (Received January 23, 2011)

1071-35-51 **Nguyen Hoang Loc** and **Klaus Schmitt*** (schmitt@math.utah.edu). *A Bernstein condition for nonlinear elliptic PDEs.*

In the early 1900s S. Bernstein introduced a growth condition with respect to u' on the nonlinear term of the ordinary differential equation $u'' + f(t, u, u') = 0,\ 0 \le t \le 1$, which guaranteed a $C^1[0, 1]$ bound on solutions depending on a $C[0, 1]$ bound. We extend this result to nonlinear elliptic PDEs showing that a $W^{1,p}$ bound for solutions may be deduced from an L^∞ bound. (Received February 02, 2011)

1071-35-55 **Nestor Guillen*** (nguillen@math.utexas.edu). *Non-local notions of curvature.*

Non-local elliptic operators have received a great deal of attention in the last couple of years. While the connection between stochastic processes and elliptic equations remains strong in the non-local (fractional order) as much as in the local (second order) case, the connection with geometry is less understood. This is a problem as geometry has been an important source of problems and insight into the nature of elliptic equations. I will discuss recent works on non-local equations that pertain to questions in differential geometry and vice versa. (Received February 07, 2011)

1071-35-60 **Zhonghai Ding*** (Zhonghai.Ding@unlv.edu), Department of Mathematical Sciences, University of Nevada Las Vegas, Las Vegas, NV 89154. *Variational justification of the dimensional scaling method in chemical physics.*

The dimensional scaling (D-scaling) technique is an innovative asymptotic expansion approach to study multi-particle systems in chemical physics. It enables the calculation of ground and excited state energies of quantum systems without having to solve the Schrödinger equation. In this talk, some recent work on the variational justification of the D-scaling technique is presented. By casting the D-scaling technique in an appropriate variational setting and studying the corresponding minimization problem, the D-scaling technique for the Schrödinger equation with power-law potentials is justified rigorously. (Received February 11, 2011)

1071-35-62 **Shu Wang*** (wangshu@bjut.edu.cn), College of Applied Sciences, Beijing University of Technology, Pingleyuan100,Chaoyang District, Beijing, 100124, Peoples Rep of China. *ON A NEW 3D MODEL FOR INCOMPRESSIBLE EULER AND NAVIER-STOKES EQUATIONS.* Preliminary report.

In this paper, we investigate some new properties of the incompressible Euler and Navier-Stokes equations by studying a 3D model for axisymmetric 3D incompressible Euler and Navier-Stokes equations with swirl. The 3D model is derived by reformulating the axisymmetric 3D incompressible Euler and Navier-Stokes equations and then neglecting the convection term of the resulting equations. Some properties of this 3D model are reviewed. Finally, some potential features of the incompressible Euler and Navier-Stokes equations such as the stabilizing effect of the convection are presented. (Received February 11, 2011)

1071-35-63 **Andrea Malchiodi*** (malchiod@sissa.it), SISSA, Via Bonomea 265, 34136 Trieste, Italy. *Improved Moser-Trudinger inequalities and singular Liouville equations.*

We consider singular Liouville equations on compact surfaces, whose study is motivated by the problem of prescribing the Gaussian curvature on surfaces with conical singularities or by self-dual abelian Chern-Simons models. We derive a new, scaling invariant improvement of the Moser-Trudinger inequality and we derive existence results via variational arguments. (Received February 13, 2011)

1071-35-64 **J. Fleckinger**, **J.-P. Gossez*** (gossez@ulb.ac.be) and **F. de Thélin**. *Maximum and antimaximum principles: beyond the first eigenvalue.*

Consider the Dirichlet problem

$$-\Delta u = \mu u + f \text{ in } \Omega,\ u = 0 \text{ on } \partial\Omega,$$

with Ω a smooth bounded domain in $I\!R^N$. The well-known maximum and antimaximum principles give informations on the sign of the solution u when the parameter μ varies near the first eigenvalue λ_1 of the corresponding homogeneous problem. Our purpose in this talk is to introduce an analogue of these two principles when μ varies near a higher eigenvalue λ_k. Nodal domains play a central role in our study, as well as, in some cases, the Payne conjecture relative to the nodal line of a second eigenfunction in the plane. (Received February 13, 2011)

1071-35-68 **R.-S. Tian*** (rushun.tian@aggiemail.usu.edu) and **Z.-Q. Wang**. *Multiple Solitary Wave Solutions of Nonlinear Schrödinger Systems.*

We study multiplicity of solitary wave solutions of nonlinear Schrödinger system of equations,

$$\begin{cases} -\Delta U_j + U_j = \mu U_j^3 + \beta U_j \sum_{k\neq j} U_k^2, & \text{in } \Omega, \\ U_j > 0 \text{ in } \Omega, U_j = 0 \text{ on } \partial\Omega, & j = 1, \cdots, N, \end{cases}$$

where Ω is a smooth and bounded (or unbounded if Ω is radially symmetric) domain in $\mathbb{R}^n$, $n \leq 3$.

Using a Z_N index theory, we obtain multiple solutions for some parameter regime in terms of the coupling constant β. The parameter β plays an important role in this process, and its value is used to estimate the number of different solution orbits.
(Received February 14, 2011)

1071-35-84 **Jong Uhn Kim*** (kim@math.vt.edu), Department of Mathematics, Virginia Tech, Blacksburg, VA 24060-0123. *The Cauchy problem for a stochastic quasi-linear symmetric hyperbolic system.*

In this talk, I will discuss the existence and uniqueness of a local smooth solution to the Cauchy problem for a quasi-linear symmetric hyperbolic system with random noise in R^d. When the noise is multiplicative satisfying some nondegenerate conditions and the initial data are sufficiently small, we show that the solution exists globally in time in probability, i.e., the probability of global existence can be made arbitrarily close to one if the initial date are small accordingly. This result can be applied to the well-known stochastic Burgers equation. (Received February 21, 2011)

1071-35-95 **Alfonso Castro***, Department of Mathematics, Harvey Mudd College, Claremont, CA 91711, and **Jorge Cossio** and **Carlos A Velez**. *Existence of seven solutions for an asymptotically linear boundary value problem.* Preliminary report.

Combining Lyapunov-Schmidt arguments, Morse indices, existence of solutions that change sign exactly once and the mountain pass theorem we prove that the boundary value problem $\Delta u + \lambda f(u) = 0$ in Ω, $u = 0$ on $\partial\Omega$ has seven solutions when $f(0) = 0$, $f'(0) \leq 0$, $f'(\pm\infty) = 1$, $tf''(t) \geq 0$, $\lambda_k < \lambda_{k+1}$, $\lambda \in (\lambda_{k+1}, \lambda_{k+1} + \epsilon)$, $k > 3$ and ϵ small. (Received February 24, 2011)

1071-35-98 **Jann-Long Chern**, National Central University, Chung-Li, Taiwan, **Changshou Lin**, National Taiwan University, Taipei, Taiwan, and **Junping Shi*** (jxshix@wm.edu), College of William and Mary, Williamsburg, VA 23187. *Uniqueness of positive solution to semilinear elliptic systems.*

The steady state solutions of a reaction-diffusion system satisfy a system of semilinear elliptic equations. While the existence of positive solutions can be shown with various ways, the uniqueness or exact multiplicity of positive solutions is difficult to obtain. We review some known results and recent work for sublinear systems and also radially symmetric solutions. (Received February 24, 2011)

1071-35-99 **Thomas Bartsch**, **Norman Dancer** and **Zhi-Qiang Wang*** (zhi-qiang.wang@usu.edu). *Bifurcation results for a nonlinear Schrödinger system.*

We discuss some work on local and global bifurcation structure of positive solutions for a nonlinear system of Schrödinger type equations, which give multiplicity results of positive bound state solutions of the system in the repulsive case. The method is a combination of variational and bifurcation arguments. (Received February 25, 2011)

1071-35-103 **Jiahong Wu*** (jiahong@math.okstate.edu), 401 Mathematical Sciences, Stillwater, OK 74078. *Recent progress on the surface quasi-geostrophic and related equations.*

Fundamental issues such as the global regularity problem concerning the surface quasi-geostrophic (SQG) and related equations have attracted a lot of attention recently. Significant progress has been made on various fronts.

This talk focuses on some very recent advances on the generalized SQG equations. These equations are active scalar equations with the velocity fields determined by the scalars through general Fourier multiplier operators. The SQG equation is a special case of these general models and it corresponds to the Riesz transform. We present several existence and uniqueness results for the case when the operators are very singular integral operators. These results are from three recent papers in collaboration with D. Chae, P. Constantin, D. Cordoba and F. Gancedo. These papers can be found in arXiv. (Received February 25, 2011)

1071-35-104 **Betul Orcan*** (orcanb@msri.org). *About the Geometry and Regularity of Largest Subsolutions for a Free Boundary Problem in R^2: Elliptic Case.*

We study geometry and regularity properties of the largest subsolution of a one-phase free boundary problem under a very general free boundary condition in R^2. Moreover, we provide density bounds for the positivity set and its complement near the free boundary. (Received February 25, 2011)

1071-35-106 **Eunkyoung Lee**, **Sarath Sasi** and **Ratnasingham Shivaji*** (shivaji@ra.msstate.edu), Department of Mathematics/CCS, Mississippi State University, Mississippi State, MS 39762. *S-Shaped Bifurcation Curves in Ecosystems.*

We consider the existence of multiple positive solutions to the steady state reaction diffusion equation with Dirichlet boundary conditions of the form:

$$\begin{cases} -\Delta u = \lambda[u - \dfrac{u^2}{K} - c\dfrac{u^2}{1+u^2}], & x \in \Omega \\ u = 0, & x \in \partial\Omega. \end{cases}$$

Here $\Delta u = div(\nabla u)$ is the Laplacian of u, $\frac{1}{\lambda}$ is the diffusion coefficient, K and c are positive constants and $\Omega \subset \mathbb{R}^N$ is a smooth bounded region with $\partial\Omega$ in C^2. This model describes the steady states of a logistic growth model with grazing in a spatially homogeneous ecosystem. It also describes the dynamics of the fish population with natural predation. In this paper we discuss the existence of multiple positive solutions leading to the occurrence of an S-shaped bifurcation curve. (Received February 25, 2011)

1071-35-116 **Silvia Cingolani**, **Mónica Clapp*** (mclapp@matem.unam.mx) and **Simone Secchi**. *Multiple solutions to a magnetic nonlinear Choquard equation.*

We consider the stationary nonlinear magnetic Choquard equation

$$(-\mathrm{i}\nabla + A(x))^2 u + V(x)u = \left(\frac{1}{|x|^\alpha} * |u|^p\right)|u|^{p-2}u, \quad x \in \mathbb{R}^N$$

where A is a real valued vector potential, V is a real valued scalar potential $N \geq 3$, $\alpha \in (0, N)$ and $2 - (\alpha/N) < p < (2N-\alpha)/(N-2)$. We assume that both A and V are compatible with the action of some group G of linear isometries of $\mathbb{R}^N$. We establish the existence of multiple complex valued solutions to this equation which satisfy the symmetry condition

$$u(gx) = \tau(g)u(x) \quad \text{for all } g \in G,\ x \in \mathbb{R}^N,$$

where $\tau : G \to \mathbb{S}^1$ is a given group homomorphism into the unit complex numbers. (Received February 27, 2011)

1071-35-124 **Jianxin Zhou*** (jzhou@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843, **Yalchin Efendiev**, Department of Mathematics, Texas A&M University, College Station, TX 77843, and **Juan Galvis**, Department of Mathematics, Texas A&M University, College Station, TX 77843. *An inequality for a two-level domain decomposition preconditioner in processing high-contrast images.* Preliminary report.

When two-level domain decomposition preconditioners are used to process high-contrast images, some of the finite element base functions in a space B represent coarse meshes and others represent fine meshes. When dealing with high-contrast images, if error is measured in L_2-norm, the graph-Laplace operator Δ is introduced. When error is measured in L_p-norm with $p \geq 2$, it leads to the graph-p-Laplace operator Δ_p. The key to develop a two-level domain decomposition preconditioner in processing high-contrast images is to solve the problem: for given iso-homogenous functions $F, G : B \to \mathbb{R}_+, \lambda_0 > 0$, find the smallest coarse mesh subspace $U \subset B$ s.t.

$$CF(u) \geq F(u - P(u)) \geq \lambda_0 G(u - P(u)), \quad \forall u \in B,$$

where B is a Banach space, $P(u)$ is the projection of u on U and C is a constant depending on $\dim(U)$ but independent of u and $\dim(B)$.

In this talk, the speaker will show that the above problem can be solved through a multiple solution approach and then use a new variational max-min method to establish its solvability, solution characterization, its Morse index and numerical algorithm for solving the problem.

This is a joint work with Drs. Yalchin Efendiev and Juan Galvis of Texas A&M university. (Received February 28, 2011)

1071-35-139 **William Layton** (wjl@pitt.edu), Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260, and **Catalin Trenchea*** (trenchea@pitt.edu), Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260. *Stability of two IMEX methods, CNLF and BDF2-AB2, for uncoupling systems of evolution equations.* Preliminary report.

Stability is proven for two second order, two step methods for uncoupling a system of two evolution equations with exactly skew symmetric coupling: the Crank-Nicolson Leap Frog (CNLF) combination and the BDF2-AB2 combination. The form of the coupling studied arises in spatial discretizations of the Stokes-Darcy problem. For CNLF we prove stability for the coupled system under the time step condition suggested by linear stability theory for the Leap-Frog scheme. This seems to be a first proof of a widely believed result. For BDF2-AB2 we prove stability under a condition that is better than the one suggested by linear stability theory for the individual methods. (Received March 01, 2011)

1071-35-152 **zhenhua GUO*** (zhenhua.guo.math@gmail.com), xi'an, shaan xi 7100769, Peoples Rep of China. *Some Develops on the Multi-dimensional Compressible Navier-Stokes Equations with Density-dependent Viscosity Coefficients.*

In this talk, I will give some new results about multi-dimensional compressible Navier-Stokes equations with density-dependent viscosity coefficients. Those results include the existence of global weak solutions, dynamical behaviors and Lagrange structure with spherically symmetric initial data, both fixed boundary conditions and free boundary conditions. (Received March 02, 2011)

1071-35-154 **John M. Neuberger*** (John.Neuberger@NAU.Edu), Department of Mathematics and Statistics, Box, Northern Arizona University, Flagstaff, AZ 86011, and **Christopher Tyler Diggans**. *Newton's Method for Nonlinear Elliptic Systems.* Preliminary report.

We consider nonlinear elliptic systems of the form

$$\Delta u + \frac{\partial}{\partial v} H_{\lambda,\mu}(u,v) = 0, \quad \Delta v + \frac{\partial}{\partial u} H_{\lambda,\mu}(u,v) = 0,$$

where $u, v : \Omega \to \mathbb{R}$ satisfy 0 Dirichlet boundary conditions and H satisfies certain superlinear and subcritical conditions. Our work is primarily numerical, whereby we apply variants of the Galerkin-Newton gradient Algorithm (GNGA, Neuberger & Swift) to follow bifurcation surfaces according to the real paramters λ and μ in $H_{\lambda,\mu}(u,v) = \frac{u^4}{4} + \frac{v^4}{4} + \lambda\frac{u^2}{2} + \mu\frac{u^2}{2}$. In our preliminary studies, we take Ω to be an interval and find solutions of all possible symmetries lying on trivial, primary, secondary, and tertiary bifurcating surfaces. Additionally, we consider the diagonal in parameter space defined by $\lambda = \mu$. Here, we relate solutions on the trivial and primary branches to solutions to a single PDE, and then demonstrate how the extra symmetry in the system leads to additional, secondary bifurcations, and bifurcations from the trivial plane for negative parameters. (Received March 03, 2011)

1071-35-169 **Jerry L. Bona*** (bona@math.uic.edu), Dept of Math, Statistics & Computer Science, University of Illinois at Chicago, 851 S. Morgan Street MC 249, Chicago, IL 60607. *Well-posedness Results for Systems of Nonlinear Dispersive Wave Equations.* Preliminary report.

The lecture will focus on recent results about well-posedness for systems of nonlinear, dispersive wave equations. (Received March 03, 2011)

1071-35-171 **Jerry L Bona**, **Hongqiu Chen*** (hchen1@memphis.edu) and **Ohannes Karakashian**. *Solitary-waves and their stability for coupled KdV-type systems of equations.*

Bona, Cohen and Wang recently studied coupled systems

$$u_t + u_{xxx} + P(u,v)_x = 0,$$
$$v_t + v_{xxx} + Q(u,v)_x = 0$$

of KdV-type equations, where $u = u(x,t), v = v(x,t)$ are functions defined for $x \in (-\infty, \infty)$ and $t \in [0, \infty)$. $P(u,v) = Au^2 + Buv + Cv^2$ and $Q(u,v) = Du^2 + Euv + Fv^2$ in which $A, B, \cdots, F$ are real number constants. They showed that under certain conditions on P and Q, the system is well-posed globally in time if the initial data $(u(x,0), v(x,0)) = (u_0(x), v_0(x))$ lies the space $H^s \times H^s$ for any $s > -\frac{3}{4}$. In this lecture, I will talk about the joint work with Bona and Karakashian on explicit solitary-wave solutions and their stability. (Received March 03, 2011)

1071-35-196 **Craig Cowan** and **Nassif Ghoussoub*** (nassif@math.ubc.ca), Department of Mathematics, University of British Columbia, Vancouver, BC V6T1Z2, Canada, and **Pierpaolo Esposito**. *Regularity of Extremal Solutions in Fourth Order Nonlinear Eigenvalue Problems on General Domains.*

We examine the regularity of the extremal solution of fourth order nonlinear eigenvalue problem on general bounded domains with the Navier boundary condition. We give general pointwise bounds and energy estimates which show that for convex and superlinear nonlinearities, the extremal solutions are smooth provided the dimensions are low. (Received March 05, 2011)

1071-35-199 **Jon Jacobsen*** (jacobsen@math.hmc.edu), CA, **Yu Jin**, , Canada, **Hannah McKenzie**, , Canada, and **Mark Lewis**, , Canada. *R_0 analysis of a spatiotemporal model for stream populations.* Preliminary report.

We consider a framework for studying population persistence in spatiotemporal models based on an infinite dimensional analogue of the basic reproductive number r_0 used in structured population models. We consider applications in the context of population persistence in streams. (Received March 05, 2011)

1071-35-203 **Quansen Jiu*** (qsjiumath@gmail.com), School of Mathematical Sciences, Capital Normal University, Beijing, 100048, Peoples Rep of China. *Axisymmetric Euler-α Equations without Swirl.*

In this talk, we will present some recent progresses on the three-dimensional axisymmetric Euler-α (also known as Lagrangian-averaged Euler-α) equations without swirl. In particular, we will show the global existence and uniqueness of weak solutions when the initial unfiltered vorticity belongs to $L^p_c(R^3)$ with $p > \frac{3}{2}$. We will also present the golbal existence of weak solutions when the initial unfiltered vorticity is a finite Randon measure with compact support. This is joint with Dongjuan Niu, Edriss S. Titi and Zhouping Xin. (Received March 06, 2011)

1071-35-206 **Zhiwu Lin*** (zlin@math.gatech.edu), School of Mathematics, 646 Cherry St., Georgia Tech, Atlanta, GA 30332. *Nonlinear Landau damping and inviscid damping.*

Consider electrostatic plasmas described by Vlasov-Poisson system with a fixed ion background. In 1946, Landau discovered the linear decay of electric field near a stable homogeneous state. The nonlinear Landau damping was recently proved for analytic perturbations by Villani and Mouhot. But for general perturbations it is still largely open. With Chongchun Zeng at Georgia Tech, we construct nontrivial traveling waves (BGK waves) with any spatial period which are arbitrarily near any homogeneous state in $H^s(s < \frac{3}{2})$ Sobolev norm of the distribution function. Therefore, the nonlinear Landau damping is NOT true in $H^s(s < \frac{3}{2})$ spaces. We also showed that in small $H^s(s > \frac{3}{2})$ neighborhoods of linearly stable homogeneous states, there exist no nontrivial invariant structures. This suggests that the long time dynamics near stable homogeneous states in $H^s(s > \frac{3}{2})$ spaces might be much simpler and the nonlinear damping might be hoped for. We also obtained similar results for the problem of nonlinear inviscid damping of Couette flow, for which the linear decay was first observed by Orr in 1907. (Received March 06, 2011)

1071-35-213 **Diego M Maldonado*** (dmaldona@math.ksu.edu), 138 Cardwell Hall, Kansas State University, Manhattan, KS 66506. *Properties of the solutions to elliptic PDEs adapted to convex functions.* Preliminary report.

We look at the regularity properties of non-negative solutions to Lu=f, where L is an elliptic, possibly degenerate, operator whose geometry and measure theory are ruled by the Hessian of a convex function. The archetypal example of such an operator is realized by the linearized Monge-Ampere operator. (Received March 06, 2011)

1071-35-216 **David Hartenstine*** (david.hartenstine@wwu.edu) and **Matthew Rudd**. *Asymptotic statistical characterizations of p-harmonic functions of two variables.*

It is well known that harmonic functions are characterized by the mean value property. Building on recent work of Manfredi, Parviainen and Rossi, we generalize this result, proving that a p-harmonic function of two variables satisfies, in a viscosity sense, two asymptotic formulas involving its local statistics. Moreover, we show that these asymptotic formulas characterize p–harmonic functions when $1 < p < \infty$. An example demonstrates that, in general, these formulas do not hold in a non-asymptotic sense. (Received March 06, 2011)

1071-35-223 **Dongjuan Niu*** (niuniudj@gmail.com), School of mathematical sciences, Capital Normal University, Beijing, 100048, Peoples Rep of China. *The behavior of helical flow at the limit of their parameters.*

It is well-known that the three-dimensional Navier-Stokes equations are invariant under helical symmetries, namely, they possess a family of solutions of the form $u(r, \kappa\theta + \alpha z)$ in the cylindrical coordinates. The talk investigate the limit behavior of the helical flows, which are known to be globally well-posed, to their two-dimensional limits as the viscosity and the corresponding helical parameters tend to zero. (Received March 07, 2011)

1071-35-240 **Roger Temam*** (temam@indiana.edu), 831 East Third St., Rawles Hall, Bloomington, IN 47405. *Well-Posedness Results for the Stochastic Primitive Equations of the Oceans and Atmosphere.*

The primitive equations are widely regarded as a fundamental description of geophysical scale fluid flows and forms the core of the most advanced numerical general circulation models (GCMs). This system may be derived from the compressible Navier- Stokes equations with a combination of empirical observation and scale analysis. In view of the wide progress made in computation the need has appeared to better understand and model some of the uncertainties which are contained in these GCMs. In this context stochastic modeling has appeared as one of the major modes in the contemporary evolution of the field.

While the mathematical theory for the deterministic primitive equations is now on a firm ground it seems that very little has been done so far on it stochastic counterpart. For this and other nonlinear SPDE's the issue of compactness remains a challenging problem especially for the case of nonlinear multiplicative noise. In this talk we discuss some recent work on the global existence and uniqueness of solutions of the primitive equations in both 2 and 3 spatial dimensions. This is joint work with A. Debussche, N. Glatt-Holtz, and M. Ziane. (Received March 07, 2011)

1071-35-242 **Katarina Jegdic*** (jegdick@uhd.edu), One Main Street, Houston, TX 77002. *A Riemann problem for two-dimensional isentropic gas dynamics equations.*

We consider a Riemann problem for two-dimensional isentropic gas dynamics equations modeling an interaction of a shock with a wedge. We rewrite the problem in self-similar coordinates and we obtain a mixed type (hyperbolic-elliptic) system and a nonlinear free boundary problem for a subsonic state. We use the theory of second order elliptic equations and fixed point arguments to prove existence of a solution to this free boundary problem. We fix the boundary within a suitable space of curves, we solve the fixed boundary problem (in a weighted Holder space) and then we update the location of the boundary. We show that this mapping on the set of admissible boundaries has a fixed point. (Received March 07, 2011)

1071-35-246 **Anna L Mazzucato***, Penn State University, University Park, PA 16802. *Approximate solutions to forward Kolmogorov equations.*

I will present an elementary method to approximate the pdf associated with general classes of continuous-time diffusion processes in the framework of forward Kolmogorov equations. This approximation is accurate to any order in the short-time limit and can be bootstrapped to large times. Numerical tests show this method works well for degenerate equations, such as those arising in pricing of contingent claims. (Received March 07, 2011)

1071-35-265 **Mihaela Ignatova** and **Igor Kukavica*** (kukavica@usc.edu). *Complexity of solutions for parabolic equations with Gevrey coefficients.*

We provide a quantitative estimate of unique continuation for high order parabolic equations (including the Navier-Stokes equations) with non-analytic Gevrey coefficients. We also provide a new upper bound for the number of spacial oscillations with polynomial dependence of coefficients. (Received March 08, 2011)

1071-35-266 **Igor Kukavica*** (kukavica@usc.edu) and **Amjad Tuffaha**. *Local well-posedness for a fluid-structure interaction model.*

In the talk we address a system of PDEs describing an interaction between an incompressible fluid and an elastic body. The fluid motion is modeled by the Navier-Stokes equations while an elastic body evolves according to an elasticity equation. On the common boundary, the velocities and stresses are matched. We discuss available results on local well-posedness and prove new existence and uniqueness results with the velocity and displacement belonging to natural low regularity spaces. (Received March 08, 2011)

37 ► Dynamical systems and ergodic theory

1071-37-31 **Joseph H Silverman*** (jhs@math.brown.edu), Mathematics Department - Box 1917, Brown University, Providence, RI 02912. *The Post-Critically Finite Locus for Cubic Polynomials.*

Let $\mathrm{M}_d^{\mathrm{crit}}$ be the moduli space of rational maps of degree d with marked critical points modulo conjugation by PGL_2, and let $C_i(N)$ be the locus of maps in $\mathrm{M}_d^{\mathrm{crit}}$ for which the i'th critical point is periodic of period dividing N. It is a consequence of Thurston's rigidity theorem that the subvarieties $C_i(N_i)$ for $1 \le i \le 2d-2$ intersect transversally. (Note that the maps in the intersection are post-critically finite.) Milnor's proof is heavily analytic, and Adam Epstein asked if one could give a more algebraic (or p-adic) proof. I will describe a 3-adic proof for cubic polynomials. Epstein has independently given a somewhat different 3-adic proof. (Received January 10, 2011)

1071-37-128 **Jon Chaika*** (jonchaika@math.uchicago.edu), Jon Chaika 411 Eckhart Hall, Dept. of Mathematics, 5734 S. University Avenue, Chicago, IL. *Quantitative shrinking target results.*

In this talk we present some quantitative shrinking target results. Consider $T : [0,1] \to [0,1]$. One can ask how quickly under T a typical point x approaches a typical point y. In particular given $\{a_i\}_{i=1}^{\infty}$ is $T^i x \in B(y, a_i)$ infinitely often? A finer question of whether $T^i x \in B(y, a_i)$ as often as one would expect will be discussed. That is, does

$$\lim_{N\to\infty} \frac{\sum_{n=1}^{N} \chi_{B(y,a_n)}(T^n x)}{\sum_{n=1}^{N} 2a_n} = 1$$

for almost every x. (Received February 28, 2011)

1071-37-151 **Lucien Szpiro** (lszpiro@gc.cuny.edu), Ph.D. Program in Mathematics, CUNY Graduate Center, 365 Fifth Avenue, New York, NY 10016, **Michael Tepper** (mlt16@psu.edu), Division of Science and Engineering, Penn State Abington, 1600 Woodland Road, Abington, PA 19001, and **Phillip O Williams*** (philwill@gmail.com), Ph.D. Program in Mathematics, CUNY Graduate Center, 365 Fifth Avenue, New York, NY 10016. *Resultant and Conductor of Geometrically Semi-stable Self Maps of the Projective Line Over a Number Field or Function Field.*

We study the minimal resultant divisor of self-maps of the projective line over a number field or a function field, and its relation to the conductor. The guiding focus is the exploration of a dynamical analog to a theorem of the first author, which bounds the degree of the minimal discriminant of an elliptic surface in terms of the conductor. Degree 2 maps in normal form with semi-stable bad reduction are used to construct a counterexample to the natural dynamical analog of this theorem. To do this, we study minimality and semi-stability, considering what conditions imply minimality and whether semi-stable models and presentations are minimal, proving results in the degree two case. Finally, we consider the notion of "critical bad reduction," and show that a dynamical analog to the theorem mentioned above may still be possible using the locus of critical bad reduction to define the conductor. (Received March 02, 2011)

1071-37-195 **Benjamin Hutz*** (bhutz@gc.cuny.edu). *Morphisms of projective space with automorphisms.* Preliminary report.

We consider the moduli space of dynamical systems on projective space up to conjugation by the projective general linear group. We address the problem of constructing all maps with a specified automorphism group using invariant theory. As time allows, we will discuss a particular family of maps on the projective line related to automorphisms, Newton iteration, and Lattès maps. (Received March 05, 2011)

39 ► Difference and functional equations

1071-39-40 **Amera H Almusharrf*** (amera.almusharrf286@topper.wku.edu) and **Ferhan Atici** (ferhan.atici@topper.wku.edu). *Fractional trigonometric Functions.* Preliminary report.

This talk will be about fractional calculus and the development of fractional trigonometry based on the multi-valued fractional generalization of the exponential function, known as Mittag-Leffler function. The Mittag-Leffler function plays an important role in the solution of fractional order differential equations. These classes of functions allow the opportunity to generalize the classical trigonometric functions to .fractional. or .generalized.

versions. First, I will give introduction and the history of the fractional calculus, Gamma function, definition of the fractional integral and derivative, and Laplace transform. Then the relationships between Mittag-Leffler function and the fractional trigonometric functions will be given. I will give a Laplace Transform table for these generalized functions in fractional calculus. Finally, I will present an application of fractional calculus for parameter estimations of one compartmental model of drug concentration in blood. (Received January 29, 2011)

41 ► Approximations and expansions

1071-41-269 **Shishen S Xie*** (xies@uhd.edu), Department of Computer and Math Sciences, University of Houston-Downtown, 1 Main Street, Houston, TX 77002. *Solving a Type of Nonlinear Integro-Differential Equations Using Variation Iteration Method.* Preliminary report.

An algorithm based on variation iteration method is developed to find the approximate solution of an initial value problem involving the nonlinear integro-differential equation

$$\frac{\partial}{\partial t}u(x,t) + \int_0^t Ru(x,s)ds = g(x,t),$$

with R being a nonlinear operator that contains partial derivatives with respect to x. Special cases of the integro-differential equation are solved using the algorithms. The approximate solution will be compared with analytical solutions. (Received March 08, 2011)

42 ► Fourier analysis

1071-42-130 **Maher M.H. Marzuq*** (maher_marzuq@yahoo.com), 84 Raymond Road, Plymouth, MA 02360. *A Note On L Convergence of Certain Cosine Sums.*

Abstract.

In this paper we obtain theorems concerning space with p=1, $0 < p < 1$ and $0 < p < .$

We will generalize some theorem of Telyakovskii [9] and Corollary of Marzuq [6] as well as Corollary of B. Ram. [8].

Key words and phrases: Bounded variation, - quasi-monotone sequence, certain cosine sums, and convergence. AMS Subject Classifications 2010, Primary 42A20, 42A32 (Received February 28, 2011)

1071-42-247 **Ludovic Perret*** (ludovic.perret@lip6.fr), LIP6 University Paris 6, 4, place Jussieu, 75005 Paris, France. *Groebner Bases Techniques in Cryptography.*

Algebraic cryptanalysis can be described as a general framework allowing to asses the security of a wide range of cryptographic schemes. The recent proposal and development of algebraic cryptanalysis is now widely considered as an important breakthrough in the analysis of cryptographic primitives. It is a powerful technique that applies potentially to a wide range of cryptosystems.

The basic principle of such cryptanalysis is to model a cryptographic primitive by a set of algebraic equations. The system of equations is constructed in such a way as to have a correspondence between the solutions of this system, and a secret information of the cryptographic primitive (for instance, the secret key of a block cipher).

The most efficient method for solving algebraic equations over a finite field is to compute a Gröbner basis. In the first part of this talk, we will give the definition/properties of such bases, and briefly recall the principle of efficient algorithms, i.e. F4/F4, for computing these bases.

In the second part of the talk, we will review recent appliactions of such techniques in public key cryptography. (Received March 07, 2011)

46 ► Functional analysis

1071-46-285 **Hafedh Herichi*** (herichi@math.ucr.edu), Mathematics department, University of California, Riverside, Riverside, CA 92521, and **Michel. L. Lapidus** (lapidus@math.ucr.edu), Mathematics department, University of California, Riverside, Riverside, 92521. *On the spectral operator and its invertibility.*

The spectral operator was introduced for the first time by M. L. Lapidus and his collaborator M. van Frankenhuijsen in their theory of complex dimensions in fractal geometry. The corresponding inverse spectral problem was

first considered by M. L. Lapidus and H. Maier in their work on a spectral reformulation of the Riemann hypothesis in connection with the question "Can One Hear The Shape of a Fractal String?". The spectral operator is defined on a suitable Hilbert space as the operator mapping the counting function of a generalized fractal string η to the counting function of its associated spectral measure. It relates the spectrum of a fractal string with its geometry. During this talk, we will be discussing some fundamental properties of this operator and present conditions ensuring its invertibility. (Received March 09, 2011)

47 ► Operator theory

1071-47-204 **John J. Coffey*** (coffey@purduecal.edu), Dept. of Mathematics, Comp. Sci., and Stat., Purdue University Calumet, 2200 169 Street, Hammond, IN 46323. *Closure properties of matrix operators with application to continuous-time Markov chains.*

This paper concerns transformations defined by multiplication by an infinite matrix on a subspace of a real sequence space. The transformations are not assumed to be bounded. We give several sets sufficient conditions for such a transformation to be closable. In particular, we consider the domain on which the transformation can be expressed as an infinite linear combination of the columns of the matrix. We apply our results to the operators asociated wtih the q-matrix for a continuous-time discrete-state-space Markov chain, and derive a sufficient condition for the Feller minmal process to be unique. (Received March 06, 2011)

51 ► Geometry

1071-51-119 **Kasra Rafi*** (rafi@math.ou.edu). *Coarse differentiation and the rank of Teichmüller space.* Preliminary report.

Let S be surface of hyperbolic type and T(S) be the Teichmüller space of S. We would like to study the group of quasi-isometries of T(S). As a first step we determine the rank of T(S), that is, the largest dimension N where a large box B in R^N can be embedded quasi-isometrically into T(S). The main tool we use is the coarse differentiation lemma. This states that, any quasi-isometric embedding, in the correct scale, is nearly an affine map. This is a joint work with Alex Eskin and Howard Masur. (Received February 27, 2011)

1071-51-272 **Anton Lukyanenko*** (Anton@Lukyanenko.net), Mathematics Department, 1409 W. Green Street, Urbana, IL 61801. *Complex Hyperbolic Mapping Problems.* Preliminary report.

Real hyperbolic space $\mathbb{H}^n_{\mathbb{R}}$ is defined by giving an n-ball an $O(n,1)$-invariant metric. Likewise, $\mathbb{H}^n_{\mathbb{C}}$ is defined using a $U(n,1)$-invariant metric on a $2n$-ball. Since $U(n) \subset O(2n)$, the structure of $\mathbb{H}^n_{\mathbb{C}}$ is more interesting, yet similar, to that of $\mathbb{H}^n_{\mathbb{R}}$. We will describe the geometry of $\mathbb{H}^n_{\mathbb{C}}$ and the standard correspondence between quasi-isometries of $\mathbb{H}^n_{\mathbb{C}}$ and quasi-symmetries of its boundary the Heisenberg group H^{n-1}. Following Tukia-Väisälä, we will show that a quasi-symmetry of H^{n-1} in fact extends to a bi-Lipschitz map on $\mathbb{H}^n_{\mathbb{C}}$. (Received March 08, 2011)

53 ► Differential geometry

1071-53-91 **Jacob Bernstein***, jbern@math.stanford.edu, and **Christine Breiner**. *A Variational Characterization of the Catenoid.*

We will discuss how to use an old result of Osserman and Schiffer to give a variational characterization of the catenoid. Namely, we will show that subsets of the catenoid minimize area within a geometrically natural class of minimal annuli. (Received February 22, 2011)

1071-53-107 **Xiuxiong Chen** and **Weiyong He*** (whe@uoregon.edu), Department of Mathematics, University of Oregon, Eugene, OR 97403. *The complex Monge-Ampere equation on compact Kahler manifolds.*

We consider the complex Monge-Ampere equation on compact Kahler manifolds M; in particular we consider the regularity problem when the volume form is in $W^{1,p}$ for some $p > 2n$. We prove that the gradient estimate and second order estimate hold, which improves the second order estimate of Aubin and Yau, and the gradient estimate of Blocki. Our results is rather optimal in some sense. (Received February 25, 2011)

1071-53-140 **Jeff A. Viaclovsky*** (jeffv@math.wisc.edu). *Rigidity and stability of Einstein metrics for quadratic curvature functionals.*

I will discuss rigidity (existence or nonexistence of infinitesimal deformations) and stability (strict local minimization) properties of Einstein metrics for quadratic curvature functionals on Riemannian manifolds. This is joint work with Matt Gursky. (Received March 01, 2011)

1071-53-141 **Maria del Mar Gonzalez** and **Jie Qing*** (qing@ucsc.edu). *Fractional conformal Laplacians and fractional Yamabe problems.*

Based on the relations between scattering operators of asymptotically hyperbolic metrics and Dirichlet-to-Neumann operators of uniformly degenerate elliptic boundary value problems, we formulate fractional Yamabe problems that include the boundary Yamabe problem studied by Escobar. We observe an interesting Hopf type maximum principle together with interplays between analysis of weighted trace Sobolev inequalities and conformal structure of the underlying manifolds, which extend the phenomena displayed in the classic Yamabe problem and boundary Yamabe problem. (Received March 01, 2011)

1071-53-177 **Martin Man-chun Li*** (martinli@stanford.edu), Stanford University, Mathematics, Bldg. 380, 450 Serra Mall, Stanford, CA 94305. *Free boundary problem for embedded minimal surfaces.*

For any smooth compact Riemannian 3-manifold with boundary, we prove that there always exists a smooth, embedded minimal surface with (possibly empty) free boundary. We also obtain a priori upper bound on the genus of such minimal surfaces in terms of the topology of the ambient compact 3-manifold. An interesting note is that no convexity assumption on the boundary is required. In this talk, we will describe the min-max construction for the free boundary problem, and then we will mention some of the main ideas in the proof. (Received March 04, 2011)

1071-53-222 **Jie Qing**, **Yuguang Shi** and **Jie Wu*** (wujie@math.pku.edu.cn), School of Mathematical Sciences, Peking University, Beijing, 100871. *Normalized Ricci flow on asymptotically hyperbolic manifolds.* Preliminary report.

We studied the normalized Ricci flow on complete non-compact manifolds. We established long time existence and convergence of the normalized Ricci flow from a non-degenerate and sufficiently Ricci pinched metric on non-compact manifolds. We also used a maximum principle to conclude that the normalized Ricci flow stays asymptotically hyperbolic when starting from an asymptotically hyperbolic metric. Therefore we were able to produce conformally compact Einstein metrics, in particular, recapture some general perturbation results of John Lee. (Received March 07, 2011)

1071-53-258 **Vincent Bonini*** (vbonini@calpoly.edu), Department of Mathematics, California Polytechnic State University, San Luis Obispo, CA 93407, and **José Espinar** and **Jie Qing**. *On Proper Horospherically Convex Hypersurfaces in $\mathbb{H}^{n+1}$ and Complete Conformal Metrics on Domains of $\mathbb{S}^n$.*

In this talk we will discuss our continued investigations on the correspondence of the theory of hypersurfaces in hyperbolic space $\mathbb{H}^{n+1}$ and conformal metrics on the conformal infinity $\mathbb{S}^n$ of hyperbolic space $\mathbb{H}^{n+1}$. Based on the prior works of Espinar, Gálvez and Mira and Bonini, Espinar and Qing, we construct a correspondence between complete, canonically oriented, properly immersed horospherically convex hypersurfaces in $\mathbb{H}^{n+1}$ with injective hyperbolic Gauss map and subdomains of the sphere $\mathbb{S}^n$ endowed with a complete metric in the conformal class of the standard round metric g_0 on $\mathbb{S}^n$ with eigenvalues of its Schouten tensor less than $\frac{1}{2}$. This correspondence is then used in an attempt to provide a unified framework for understanding the correspondence between elliptic problems associated with Weingarten hypersurfaces in hyperbolic space $\mathbb{H}^{n+1}$ and conformally invariant elliptic equations on subdomains of the conformal infinity $\mathbb{S}^n$. (Received March 08, 2011)

54 ► General topology

1071-54-238 **Liljana Babinkostova*** (liljanababinkostova@boisestate.edu), 1910 University Dr., Boise, ID 83725. *Topological groups and covering dimension.*

We introduce the selective screenability property for topological groups and consider a natural way of extending the Lebesgue covering dimension to various classes of infinite dimensional topological groups. The dimension function that we introduce extends Lebesgue covering dimension, has the hereditary property, and has a product theory that is more similar to the product theory for the finite dimensional case. (Received March 07, 2011)

55 ► Algebraic topology

1071-55-52 **Noureen Khan***, UNT Dallas, 7300 Houston School Rd., Dallas, TX 75007, and **M Dabkowski**. *Equivalence Classes of Knots and Links of two components in Family 6* modulo 4-moves.*

Let L be a knot or a link of two components described by 6*a.b.c.d.e.f , where a, b, c, d, e and f are 2-algebraic tangles with no closed components. Then L is reduced by 4-moves to trivial knot or trivial link of two components or to Hopf link. (Received February 04, 2011)

1071-55-147 **Max Forester*** (forester@math.ou.edu), Mathematics Department, University of Oklahoma, Norman, OK 73019. *Promotion maps and Smith theory.*

This talk concerns the situation of a finite group acting on a space. I will discuss a new natural homomorphism which is closely related to the transfer, called promotion. Applications include new and elementary proofs of some of the classical results of Smith theory. The talk will be elementary; no prior knowledge of Smith theory is required. (Received March 02, 2011)

57 ► Manifolds and cell complexes

1071-57-33 **Joshua Evan Greene*** (josh@math.columbia.edu). *Conway mutation and alternating links.*

We prove that a reduced, alternating link diagram is determined up to mutation by the Heegaard Floer homology of the link's branched double cover. Thus, alternating links with homeomorphic branched double covers are mutants. We will mention some consequences of this result and give an indication of the proof, which involves studying the lattice of integral flows on a finite graph. (Received January 16, 2011)

1071-57-47 **Hao Wu*** (haowu@gwu.edu). *Colored Morton-Franks-Williams inequalities.*

We generalize the Morton-Franks-Williams inequality to the colored $\mathfrak{sl}(N)$ link homology, which gives infinitely many new bounds for the braid index and the self linking number. A key ingredient of our proof is a composition product for the general MOY graph polynomial, which generalizes that of Wagner. (Received February 02, 2011)

1071-57-48 **John A Baldwin*** (baldwinj@math.princeton.edu) and **Adam S Levine**. *A spanning tree model for delta-graded knot Floer homology.*

I shall outline a new combinatorial formulation of delta-graded knot Floer homology, expressed in terms of spanning trees of the black graph of a link projection. Our construction comes from iterating Manolescu's unoriented skein exact triangle using twisted coefficients. (Received February 02, 2011)

1071-57-49 **Paul Kirk***, Rawles Hall, Indiana University, Bloomington, IN , and **Matt Hedden**. *Linear independence of Whitehead doubles of torus knots.*

We show that certain infinite families of untwisted Whitehead doubles, for example the Whitehead doubles of the $(2, 2^n - 1)$ torus knots, are linearly independent in the knot concordance group. (Received February 02, 2011)

1071-57-93 **Cynthia L. Curtis*** (ccurtis@tcnj.edu), Department of Mathematics and Statistics, The College of New Jersey, Ewing, NJ 08628, and **Samuel J. Taylor**. *The Jones polynomial and boundary slopes of alternating knots.*

We show for an alternating knot the minimal integral boundary slope is given by the signature plus twice the minimum degree of the Jones polynomial and the maximal integral boundary slope is given by the signature plus twice the maximum degree of the Jones polynomial. For alternating Montesinos knots, these are the minimal and maximal boundary slopes. (Received February 23, 2011)

1071-57-96 **Charles Livingston** and **Cornelia A. Van Cott*** (cvancott@usfca.edu). *Concordance of Bing doubles and boundary genus.*

In 2008, Cha and Kim proved that if a knot K is not algebraically slice, then no iterated Bing double of K is concordant to the unlink. We observe that if K has nontrivial signature σ, then the n^{th}–iterated Bing double of K is not concordant to any boundary link with boundary surfaces of genus less than $2^{n-1}\sigma$. The same result holds with σ replaced by 2τ, twice the Ozsváth-Szabó knot concordance invariant. (Received February 24, 2011)

1071-57-118 **Thomas Koberda*** (koberda@math.harvard.edu), Department of Mathematics, 1 Oxford St., Cambridge, MA 02138. *Mapping classes, finite covers and large hyperbolic 3–manifolds.* Preliminary report.

We will consider a Torelli mapping class ψ on a surface Σ and examine its action on the real homology of each finite abelian cover of Σ. We will see that either there is a finite abelian cover Σ' of Σ where ψ acts with spectral radius strictly larger than one on $H_1(\Sigma', \mathbb{R})$, or the suspension of the mapping class M_ψ is a 3–manifold with a large fundamental group. It follows that if ψ is in the Magnus kernel, $\pi_1(M_\psi)$ is always large. (Received February 27, 2011)

1071-57-129 **Rena M.H. Levitt*** (rlevitt@cmc.edu), Department of Mathematics & Computer Science, Claremont McKenna College, 850 Columbia Avenue, Claremont, CA 91711. *A Combinatorial Curvature Condition for Triangle-Square Complexes.* Preliminary report.

In both CAT(0) cubical and systolic complexes, the curvature condition can be expressed as a simple combinatorial condition on links. These criteria are very useful in studying group actions on such spaces. In this talk I will discuss a combinatorial curvature condition satisfied by CAT(0) triangle-square complexes, similar to Damian Osajda's weakly systolic condition. (Received February 28, 2011)

1071-57-142 **Scott Baldridge*** (sbaldrid@math.lsu.edu), 224 Lockett Hall, Department of Mathematics, Baton Rouge, LA 70803. *Knotted tori in $\mathbb{R}^4$ and hypercube diagrams.*

In this talk we will introduce a new representation of an embedded knotted torus in $\mathbb{R}^4$ called a hypercube diagram, i.e., a 4-dimensional grid diagram. We will present a few examples of knotted tori and discuss invariants derived from hypercube diagrams. (Received March 01, 2011)

1071-57-187 **Masaharu Ishikawa** (ishikawa@math.tohoku.ac.jp), **Thomas W Mattman*** (TMattman@CSUChico.edu) and **Koya Shimokawa** (kshimoka@rimath.saitama-u.ac.jp). *Tangle sums and factorization of A-polynomials.*

We show that there exist infinitely many examples of pairs of knots, K_1 and K_2, that have no epimorphism $\pi_1(S^3 \setminus K_1) \to \pi_1(S^3 \setminus K_2)$ preserving peripheral structure although their A-polynomials have the factorization $A_{K_2}(L, M) \mid A_{K_1}(L, M)$. Our construction accounts for most of the known factorizations of this form for knots with 10 or fewer crossings. In particular, we conclude that while an epimorphism will lead to a factorization of A-polynomials, the converse generally fails. (Received March 04, 2011)

1071-57-188 **Matthew Hedden*** (mhedden@math.msu.edu), East Lansing, MI 48824, and **Yi Ni** (yini@caltech.edu), Pasadena, CA. *Unlink detection and the Khovanov module.* Preliminary report.

Kronheimer and Mrowka recently showed that Khovanov homology detects the unknot. Their proof does not obviously extend to show that Khovanov homology detects unlinks of more than one component, and one could reasonably question whether it actually does (the Jones polynomial, for instance, does not detect unlinks with multiple components). In this talk, I'll discuss how to use a spectral sequence of Ozsvath and Szabo in conjunction with Kronheimer and Mrowka's result to settle the question (in the affirmative). This is joint work with Yi Ni. (Received March 04, 2011)

1071-57-193 **T.J. Gaffney*** (gaffney.tj@gmail.com). *Khovanov Homology on Certain Symmetric Unions.* Preliminary report.

Symmetric unions of knots are often difficult to distinguish from one another. For example, the Alexander polynomial can only detect the parity of the winding used in their construction. We were able to show that Khovanov homology can distinguish, and in fact completely classify, the symmetric unions of the families of (2,n)-torus knots and certain 2-bridge knots. (Received March 05, 2011)

1071-57-208 **Thomas E. Mark*** (tmark@virginia.edu), Department of Mathematics, PO Box 400137, University of Virginia, Charlottesville, VA 22902. *Symplectic surgeries from mapping class group relations.*

We interpret several families of cut-and-paste operations on 4-manifolds in terms of relations in the mapping class groups of planar surfaces: we exhibit families of relations generalizing the classical lantern relation, giving rise via monodromy substitution in Lefschetz fibrations to various rational blowdown operations. We also indicate some work in progress with D. Gay allowing a unified proof that these and potentially many other 4-dimensional operations may be performed symplectically. (Received March 06, 2011)

1071-57-211 **Hans U. Boden*** (boden@mcmaster.ca) and **Eric Harper** (harper@cirget.ca). *An SU(n) Casson-Lin invariant for links with n components.*

In 1992, X.-S. Lin introduced a Casson-type invariant $h(K)$ for knots $K \subset S^3$ that counts conjugacy classes of irreducible $SU(2)$ representations of the knot group $G_K = \pi_1(S^3 \setminus K)$ with meridional trace equal to -2. Lin identified $h(K)$ with the signature of the knot, and his approach was generalized to give invariants for other trace conditions and for knots in homology 3-spheres independently by C. Herald in 1997 and by M. Heusener and J. Kroll in 1998. In [Pac. J. Math. **248** (2010), 139–154], E. Harper and N. Saveliev define a Casson-Lin type invariant $h(L)$ for 2-component links $L \subset S^3$ and show $h(L)$ equals the linking number.

This talk is a report on recent joint work with Eric Harper introducing analogous invariants for n-component links $L \subset S^3$. The invariants, denoted $h_{n,d}(L)$, are given for d relatively prime to n and are defined as a signed count of conjugacy classes of certain projectively flat $SU(n)$ invariants of the link group $G_L = \pi_1(S^3 \setminus L)$. The talk will outline the compactness and irreducibility results needed to show that $h_{n,d}(L)$ is well-defined, and further that $h_{n,d}(L)$ vanishes if L is a split link. (Received March 06, 2011)

1071-57-217 **Gyo Taek Jin*** (jingyotaek@kaist.ac.kr), Department of Mathematical Sciences, KAIST, Daejeon, 305-701, South Korea, and **Hwa Jeong Lee** (hjwith@kaist.ac.kr), Department of Mathematical Sciences, KAIST, Daejeon, South Korea. *Prime knots whose arc index is smaller than the crossing number.*

A knot can be embedded in a book of finitely many half planes in the 3-dimensional Euclidean space so that each half plane intersects the knot in a simple arc. The minimal number of half planes needed for such an embedding of a knot is called the arc index of the knot. It is known that the arc index of alternating knots is the minimal crossing number plus two and that the arc index of prime nonalternating knots is less than or equal to the minimal crossing number. In this work, we show that the existence of certain local diagrams indicates that the arc index is strictly less than the crossing number. We also give a list of 13 crossing prime nonalternating knots whose arc index is 12. (Received March 06, 2011)

1071-57-235 **Uwe Kaiser*** (kaiser@math.boisestate.edu), Department of Mathematics, Boise State University, 1910 University Drive, Boise, ID 83725-1555. *Bar-Natan modules and tunneling graphs.* Preliminary report.

We describe a general method for presentations of colimit modules of functors into module catgeories. This is applied to the Bar-Natan functor, which is defined on a category of surfaces embedded in a 3-manifold M with morphisms defined by certain 3-manifolds embedded in $M \times [0,1]$ and takes values in a category of modules defined from a commutative Frobenius algebra. The colimit of the Bar-Natan functor is the Bar-Natan module of M. Our approach naturally leads to the definition of the tunneling graph of M, which contains the geometric data necessary to deduce the structure of the Bar-Natan module. (Received March 07, 2011)

1071-57-236 **Danny Calegari** and **Joel Louwsma*** (louwsma@caltech.edu), Department of Mathematics 253-37, California Institute of Technology, Pasadena, CA 91125. *Immersed surfaces in the modular orbifold.*

A hyperbolic conjugacy class in the modular group $\mathrm{PSL}(2,\mathbb{Z})$ corresponds to a closed geodesic in the modular orbifold. Some of these geodesics virtually bound immersed surfaces, and some do not; the distinction is related to the polyhedral structure in the unit ball of the stable commutator length norm. We prove the following stability theorem: for every hyperbolic element of the modular group, the product of this element with a sufficiently large power of a parabolic element is represented by a geodesic that virtually bounds an immersed surface. (Received March 07, 2011)

1071-57-251 **Tim D Cochran*** (cochran@rice.edu), MS-136 Math. department, PO Box 1892, Houston, TX 77251-1892, and **Bridget D Franklin**, **Matthew Hedden** and **Peter D Horn**. *Knot Concordance and Homology Cobordism.*

We consider the question: "If the zero-framed surgeries on two oriented knots in the 3-sphere are integral homology cobordant, preserving the homology class of the positive meridians, are the knots themselves concordant?" We show that this question has a negative answer in the smooth category, even for topologically slice knots. To show this we first prove that the zero-framed surgery on K is Z-homology cobordant to the zero-framed surgery on many of its winding number one satellites P(K). Then we prove that in many cases the tau and s-invariants of K and P(K) differ. Consequently neither tau nor s is an invariant of the smooth homology cobordism class of the zero-framed surgery. We also show, that a natural rational version of this question has a negative answer in both the topological and smooth categories, by proving similar results for K and its (p,1)-cables. (Received March 07, 2011)

1071-57-252 **Tim D. Cochran** (cochran@rice.edu), Dept of Mathematics, MS #136, Rice University, 6100 Main St., Houston, TX 77005, **Shelly Harvey*** (shelly@rice.edu), Dept. of Mathematics, MS #136, Rice University, 6100 Main St., Houston, TX 77005, and **Peter D. Horn** (pdhorn@math.columbia.edu), Columbia University, Department of Mathematics, MC 4403, 2990 Broadway, New York, NY 10027. *Filtering smooth concordance classes of topologically slice knots.*

In the late 90's, Tim Cochran, Kent Orr, and Peter Teichner defined the (n)-solvable filtration, $\{F_n\}$, of the smooth knot concordance group, C, which provided a framework for many advances in the study of knot concordance. However it is useless for studying the subgroup, T, of topologically slice knots. We define and investigate new filtrations of C: the n-positive filtration $\{P_n\}$, the n-negative filtration $\{N_n\}$, and their intersection $\{NP_n\}$, which is a filtration by subgroups. These are essentially refinements of $\{F_n\}$. From these we get a filtration on the subgroup of topologically slice T by setting $T_n = NP_n \cap T$. We use Casson-Gordon invariants and d-invariants from Heegaard Floer homology to show that this is a non-trivial filtration at the lower levels, that is T_0/T_1 and T_1/T_2 are non-trivial. We will also give evidence, using Heegaard Floer d-invariants and L^2 rho-invariants, that T_n/T_{n+1} is highly non-trivial for each n. (Received March 07, 2011)

1071-57-256 **Andrew Putman*** (andyp@rice.edu), Department of Mathematics, Rice University, MS 136, 6100 Main St., Houston, TX 77005, and **Ben Wieland**. *Abelian quotients of subgroups of the mapping class group and higher Pyrm representations.*

A well-known conjecture asserts that the mapping class group of a surface (possibly with punctures/boundary) does not virtually surject onto Z if the genus of the surface is large. We prove that if this conjecture holds for some genus, then it also holds for all larger genera. We also prove that if there is a counterexample to this conjecture, then there must be a counterexample of a particularly simple form. We prove these results by relating the conjecture to a family of linear representations of the mapping class group that we call the higher Prym representations. They generalize the classical symplectic representation. (Received March 08, 2011)

1071-57-276 **John R Burke*** (jrburke@wesleyan.edu), Department of Mathematics and Computer Scienc, 265 Church Street, Middletown, CT 06457. *The significances of links in knot concordance.* Preliminary report.

In the talk, we will define the concordance group of knots and discuss the n-solvable filtration of this group de fined by Cochran, Orr, and Teichner. We will then discuss some of the previous results about the structure of the concordance group, in particular, the structure of the abelian quotient groups, G_n, of n-solvable knots modulo $n : 5$-solvable knots. We will end by discussing how by using genetic infection with string links and not knots alone one can construct knots in G_n which are linearly independent from previously studied knots. (Received March 08, 2011)

1071-57-280 **Jae Choon Cha** and **Kent E Orr*** (korr@indiana.edu), 831 E. 3rd Street, Department of Mathematics, Bloomington, IN 47405. *Homology cobordism of 3-manifolds and Cheeger-Gromov invariants.*

We discuss recent progress in understanding homology cobordism of 3-manifolds, hidden torsion, and Cheeger-Gromov invariants. (Received March 08, 2011)

1071-57-281 **James F. Davis*** (jfdavis@indiana.edu) and **Shmuel Weinberger**. *Mapping tori of self-homotopy equivalences of lens spaces.*

Here is a conjecture: If the mapping torus of a self-homotopy equivalence of a closed 3-manifold is homotopy equivalent to a closed 4-manifold, then the mapping torus is homotopy equivalent to a manifold which fibers over the circle.

We prove this conjecture in the case of a lens space.

As a consequence we answer a question of Jonathan Hillman and show that closed 4-manifold with Euler characteristic zero and fundamental group the semidirect product of a infinite cyclic group acting on a finite cyclic group has the homotopy type of a manifold with the geometry of SO(3) x R.

The methods involve rho invariants and surgery. (Received March 08, 2011)

1071-57-282 **Constance Leidy*** (cleidy@wesleyan.edu), 265 Church Street, Middletown, CT 06457, and **Tim Cochran** and **Shelly Harvey**. *The fractal nature of knot concordance.*

We describe new group series that yield filtrations of the knot concordance group that refine the (n)-solvable filtration. The new filtrations allow us to distinguish between knots whose classical Alexander polynomials are coprime and even to distinguish between knots with coprime higher-order Alexander polynomials. We use these

techniques to give evidence that the set of smooth concordance classes of knots is a fractal set. (Received March 08, 2011)

58 ► Global analysis, analysis on manifolds

1071-58-197 **Vyron Sarantis Vellis*** (vellis1@illinois.edu), 805 West Green Street, Appartment A25, Urbana, IL 61801. *Quasispheres generated by quasicircles.*

We present a construction of higher dimensional quasispheres from planar quasicircles. In particular, let Σ_1 be any planar bounded quasicircle, and Ω_2 be the closure of the bounded component of $\mathbb{R}^2 \setminus \Sigma_1$. Define inductively for $n \geq 2$, an n-dimensional surface

$$\Sigma_n = \{(x, z) \in \mathbb{R}^{n+1} \text{ with } x \in \Omega_n \text{ and } |z| = \text{dist}(x, \Sigma_{n-1})\}$$

and define Ω_{n+1} to be the closure of the bounded component of $\mathbb{R}^{n+1} \setminus \Sigma_n$. We show that Σ_n is a quasisphere in $\mathbb{R}^{n+1}$. Also, define for $\alpha \geq 0$, the 2−dimensional surface

$$\Sigma_2^\alpha = \{(x, z) \in \mathbb{R}^3 \text{ with } x \in \Omega_2, |z| = \text{dist}(x, \Sigma_1)^\alpha\}.$$

From the above result Σ_2^1 is always quasisphere. But it is well known that Σ_2^0 is not a quasisphere when Σ_1 is nonrectifiable. For $\alpha \neq 0, 1$, we show among other results that Σ_2^α is not a quasisphere when Σ_1 is the Von Koch snowflake. (Received March 05, 2011)

60 ► Probability theory and stochastic processes

1071-60-25 **Pourya Hajyalikhani*** (pourya_alikhani@yahoo.com), Civil Engineering, University of Texas at Arlington, Box 19308, Arlington, TX 76019, and **Zoha Niazi** and **Mostafa Ghandehari**. *Triangular Distribution for Scheduling of Construction.* Preliminary report.

Data for duration of construction projects is modeled as a triangular distribution. The mean, variance and the third moment is used to estimate parameters . After algebraic transformations symmetric functions on three parameters are solutions of a cubic equation. A goodness of fit test validates the results. (Received December 23, 2010)

1071-60-34 **Hakima Bessaih*** (bessaih@uwyo.edu), Dept. 3036, 1000 East University Avenue, Laramie, WY 82071, and **Benedetta Ferrario**. *Stationary Gibbs measures for shell models of turbulence: the viscous and inviscid case.* Preliminary report.

We construct a family of probability measures of Gibbsian type associated to some inviscid shell models of turbulence which carries a flow leaving this measure invariant. This measure is supported by a Sobolev space of negative exponent and is also invariant for a stochastic process associated with a viscous shell model stochastically perturbed by a white noise force. (Received January 20, 2011)

1071-60-90 **Paul J. Atzberger*** (atzberg@gmail.com), 6712 South Hall, UCSB, Santa Barbara, CA 93106. *Stochastic Eulerian Lagrangian Methods for Fluid-Structure Interactions Subject to Thermal Fluctuations.*

Traditional approaches to the mechanics of fluid-structure interaction must be extended at sufficiently small length and time scales to account for spontaneous thermal fluctuations. We present a set of new approaches which address central mathematical, physical, and computational issues concerning how to incorporate thermal fluctuations in descriptions of fluid-structure interactions. We address important numerical issues in the approximation of the resulting Stochastic Partial Differential Equations (SPDEs). This includes new approaches to obtain consistent discretizations in space and new exponential time step methods for integration in time of SPDEs. As specific application of the methodology, we discuss simulation results for models of colloidal systems, polymeric fluids, vesicles, gels, and lipid bilayer membranes. (Received February 22, 2011)

1071-60-97 **Sergey V Lototsky*** (lototsky@usc.edu), Department of Mathematics, USC, 3620 S Vermont Av., KAP 108, Los Angeles, CA 90808. *Linear filtering of stochastic evolution equations.*

Consider a stochastic evolution equation (hyperbolic or parabolic). Assume that the equation is diagonalizable (that is, can be solved by the Fourier series method) and that the coefficients in the equation are unobservable Gaussian processes. If the solution of the equation is observable, then the first N Fourier coefficients of the solution become the observation process in a conditionally Gaussian filtering model. The filter estimate of the

coefficients is then constructed using a generalized Kalman-Bucy filter, and the variance of the filter is shown to converge to zero as N grows to infinity. (Received February 24, 2011)

1071-60-113 **Zhijian Wu*** (zwu@as.ua.edu), Department of Mathematics, The University of Alabama, Tuscaloosa, AL 35487, **Chunhui Yu** (chunhui.yu@aamu.edu), Department of Mathematics, Alabama A&M University, Normal, AL 35762, and **Xiaohua Zheng** (xzheng5@bama.ua.edu), Department of Mathematics, The University of Alabama, Tuscaloosa, AL 35487. *Volatility Analysis for High Frequency Financial Data.* Preliminary report.

Measuring and modeling financial volatility are key steps for derivative pricing and risk management. In this paper, by generalizing the Ito isometry, we analyze the convergence of the realized volatility. We conclude that using certain higher order estimators of the quadratic variation would not improve the convergence rate. (Received February 25, 2011)

1071-60-163 **Kunwoo Kim*** (kkim27@illinois.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W Green st, Urbana, IL 61801, and **Richard Sowers** (r-sowers@illinois.edu) and **Zhi Zheng** (zzheng4@illinois.edu). *A Stochastic Stefan Problem.*

The classical Stefan problem describes phase change phenomena in solid- liquid systems. In this talk, we consider the one-dimensional Stefan problem perturbed by noise which is spatially correlated but white in time. We will see how the noise affects to the system and consider the existence and uniqueness of solutions. This is a joint work with Richard Sowers and Zhi Zheng. (Received March 03, 2011)

1071-60-176 **Daniel Conus*** (conus@math.utah.edu), University of Utah, Dept. of Mathematics, 155 S 1400 E, JWB 233, Salt Lake City, UT 84112. *Itô-Taylor expansions for the solution to non-linear stochastic parabolic and hyperbolic spde's.*

Using Walsh's stochastic integral, we study properties of multiple integrals. With this tool, we develop finite order Itô-Taylor expansions for the solution of non-linear parabolic and hyperbolic spde's. In some cases, we obtain convergence to the solution as the order increases. Some ideas for the proof are presented.

Joint work with Prof. Robert C. Dalang (EPFL, Lausanne, Switzerland) (Received March 04, 2011)

1071-60-185 **Pejman Mahboubi*** (pejman@math.ucla.edu). *Existence and regularities of the density of the solution of a stochastic heat equation.*

We study the smoothness of the density of the SPDE $\partial_t u = Lu + \sigma(u)\dot{W}$, where L is the L^2-generator of a Lévy process on torus, acting on only on x. The initial condition is periodical. We use techniques of Malliavin calculus to show that the law of the solution has density with respect to the Lebesgue measure on almost all t and x. (Received March 04, 2011)

1071-60-190 **Chia Ying Lee*** (chia_ying_lee@brown.edu), 182 George Street, Providence, RI 02912, and **Boris Rozovsky** (boris_rozovsky@brown.edu), 182 George Street, Providence, RI 02912. *Unbiased Perturbations of the Navier-Stokes Equation: Steady state solutions and long time convergence.*

We consider a new class of stochastic perturbations of the Navier-Stokes equation. A unique feature of such a perturbation is the preservation of the mean dynamics: the expectation of the solution of the perturbation solves the underlying deterministic Navier-Stokes equation, and may thus be construed as an unbiased random perturbation of the deterministic equation. We will discuss the steady state solutions as well as the convergence of time-dependent solutions to steady state. For several of our results, we will see that the sufficient conditions for the results to hold turn out to be similar or identical to those in analogous results for the unperturbed deterministic equation. (Received March 04, 2011)

1071-60-214 **Frederi G Viens*** (viens@purdue.edu), Deparment of Statistics, Purdue University, 150 N. University St, West Lafayette, IN 47907-2067. *New Malliavin calculus techniques for densities, and applications to stochastic PDEs.*

We describe a new Malliavin-calculus analysis of density calculations, which can shed new light on the behavior of many stochastic systems, particularly for sharp lower bound results on stochastic heat equations and their associated polymer models. We will also mention some open questions on how to generalize the techniques to non-scalar problems. This talk will cover papers by the following individuals: H. Airault, P. Malliavin, I. Nourdin, D. Nualart, G. Peccati, Ll. Quer, and F. Viens. (Received March 06, 2011)

1071-60-221 **Jason Swanson***, University of Central Florida, Department of Mathematics, 4000 Central Florida Blvd, P.O. Box 161364, Orlando, FL 32816. *A change of variable formula with Itô correction term.*

We consider the solution $u(x,t)$ to a stochastic heat equation in one spatial dimension. For fixed x, the process $F(t) = u(x,t)$ has a nontrivial quartic variation. It follows that F is not a semimartingale, so a stochastic integral with respect to F cannot be defined in the classical Itô sense. We show that for sufficiently differentiable functions $g(x,t)$, a stochastic integral $\int g(F(t),t)\,dF(t)$ exists as a limit of discrete, midpoint style Riemann sums, where the limit is taken in distribution in the Skorohod space of càdlàg functions. Moreover, we show that this integral satisfies a change of variables formula with a correction term that is an ordinary Itô integral with respect to a Brownian motion that is independent of F. (Received March 07, 2011)

1071-60-284 **Nathan E Glatt-Holtz*** (negh@indiana.edu), Department of Mathematics, Bloomington, IN 47405, and **Igor Cialenco**. *Parameter Estimation for Nonlinear Stochastic Partial Differential Equations.*

While the general form of a model is commonly derived from the fundamental properties of a physical process under study, frequently parameters arise in the formulation which need to be specified or determined on the basis of empirical observation. Given in particular the growing significance of nonlinear stochastic partial differential equations (SPDE) in applications there is a clear need to develop the theory of parameter estimation for such systems. Under the assumption that a phenomenon of interest follows the dynamics of such an SPDE, and given that some realizations of this process are measured, we wish to find these unknown parameters appearing in the model, such that the equations fit or predict as much as possible this observed data. In this work we discuss some recent results concerning the estimation of the 'drift' parameter for a general class of nonlinear SPDE, based on the first N Fourier modes of a single sample path observed on a finite time interval. In particular, we exhibit specific estimators for the viscosity coefficient for the 2D stochastic Navier-Stokes equations, and study asymptotic properties of these estimators.

This talk is based on recent joint work with Igor Cialenco (Received March 08, 2011)

62 ► Statistics

1071-62-262 **Yongmin Zhang*** (yongmin.zhang@nottingham.edu.cn), University of Nottingham Ningbo China, 199 Taikang East Road, University Park, Ningbo, Zhejiang 315100, Peoples Rep of China. *Risk Management in Mortgage Market.*

U. S. home mortgages amounted to roughly $10 trillion out of $30 trillion total domestic, non-financial borrowings according to Federal Reserve. The mortgage industry faces many risks during the whole life cycle of mortgage from origination of new loans in primary markets to packing and sale of mortgage backed securities to secondary markets. Here we are concerned about risk management in mortgage pipelines which are groups of mortgage waiting to be financed. In this talk, we will discuss various strategies to hedge the interest rate risks using capital market instruments. We will also present a valuation model for an inefficient American put option which the borrower has the right to exercise. The value of the option is the cost of hedge from the lender's point of view. (Received March 08, 2011)

65 ► Numerical analysis

1071-65-1 **Hector D Ceniceros*** (hdc@math.ucsb.edu), Department of Mathematics, University of California Santa Barbara, Santa Barbara, CA 93110. *Immersed boundaries in complex fluids.*

The interaction of flexible free-to-move boundaries with non-Newtonian (complex) fluids is receiving increased attention. Accurately capturing the coupled dynamics of this intricate flow-structure interaction is a challenging computational problem. The Immersed Boundary (IB) Method provides a versatile tool for this type of systems. However, even in the Newtonian fluid case, strong tangential forces on the immersed structures induce a well-known, severe time-step restriction for explicit discretizations. Moreover, as the number of immersed elements increases, the direct evaluation of the flow-structure interaction becomes computationally expensive. We will present a new approach that overcomes these two difficulties and yields a fast and non-stiff IB Method both in 2D and 3D. We will then discuss our progress in the investigation of peristaltic pumping in a simple model of a viscoelastic fluid in 3D. (Received March 07, 2011)

1071-65-11 **Y M Warnapala**, **J Pleskunas** and **R Siegel*** (rsiegel410@g.rwu.edu). *The Numerical solution of the exterior boundary value problems for the Helmholtz's equation via modified Green's functions approach for the Pseudosphere.* Preliminary report.

We use the global Galerkin method to numerically solve the exterior Neumann and Dirichlet problems for the Helmholtz equation for the Pseudosphere in three dimensions based on Jones' modified integral equation approach. This method was was used previously for the Sphere, Perturbation of the Sphere, Ellipsoid and for the Oval of Cassini and good convergence results were obtained. Theoretical and computational details of the method for small values of k for the pseudosphere will be presented. (Received November 09, 2010)

1071-65-16 **Andrea Bonito***, Department of Mathematics, 3368 TAMU, College Station, TX 77843, and **Irene Kyza**, **Ricardo H. Nochetto** and **Miguel S. Pauletti**.
Arbitrary-Lagragian-Eulerian Numerical Simulation of Biomembranes. Preliminary report.

Lipids molecules consist of a hydrophilic head group and a hydrophobic tail. When they are immersed in aqueous environment they aggregate spontaneously into 2 mono-molecular layers or (bio)membranes and form an encapsulating bag called vesicle.

The membrane is characterized by its Canham-Helfrich energy (Willmore energy with area constraint) and acts as a boundary force on the Navier-Stokes system. Forth order, highly nonlinear arising problems are solved using an adaptive finite element method. We present our method, emphasize the critical role of adaptivity, and discuss the numerical treatment of Arbitrary-Lagrangian-Eulerian formulation. (Received November 30, 2010)

1071-65-26 **Vrushali A. Bokil*** (bokilv@math.oregonstate.edu), 368 Kidder Hall, Department of Mathematics, Oregon State University, Corvallis, OR 97331. *An Analysis of the Uniaxial PML Model For Maxwell's Equations in Dispersive Media.* Preliminary report.

We study the Uniaxial Perfectly matched layer (UPML) model applied to Maxwell's equations in linear dispersive media using energy techniques. We consider the two dimensional TE mode of Maxwell's equations along with single pole Debye and Lorentz polarization models. We obtain uniform in time stability results under certain assumptions on the UPML parameters. We also obtain some energy decay results under additional assumptions on the UPML parameters, indicating the absorbing properties of the UPML model. Next, we consider the discretization of the UPML model using the lowest order Nédélec edge finite elements. Based on the energy decay results of the continuous model, we investigate the stability of the Nédélec method for discretizing the UPML model. (Received December 31, 2010)

1071-65-37 **Fatih Celiker*** (celiker@math.wayne.edu), Wayne State University, Department of Mathematics, 656 W. Kirby, Detroit, MI 48202, and **Bernardo Cockburn** and **Ke Shi**.
Hybridizable discontinuous Galerkin methods for higher order partial differential equations.

We introduce a new hybridizable discontinuous Galerkin (HDG) method for solving higher order elliptic and parabolic problems. We first develop the framework on the model biharmonic problem $\Delta^2 u = f$. We rewrite the biharmonic problem as a first order system for separate unknowns u, ∇u, Δu, and $\nabla\Delta u$, then we introduce the HDG method for which the only globally coupled degrees of freedom are those of the approximation to u and Δu on the faces of the elements. Therefore, the methods are efficiently implementable. We display numerical results which indicate that a suitable choice of the numerical traces results in optimal convergence for all the unknowns except for the approximation to $\nabla\Delta u$ which converges with order $k+1/2$ when polynomials of degree at most k are used. We then show how our framework can be generalized in a straightforward fashion to more challenging problems such as the Reissner-Mindlin plate model. We also show how the method can be applied to time-dependent problems as well as higher (even) order partial differential equations. (Received January 23, 2011)

1071-65-44 **Maxim A Olshanskii** and **Leo G Rebholz*** (rebholz@clemson.edu). *Application of barycenter refined meshes in linear elasticity and incompressible fluid dynamics.* Preliminary report.

The paper demonstrates that enhanced stability properties of some finite element methods on barycenter refined meshes enables efficient numerical treatment of problems involving incompressible or nearly incompressible media. One example is the linear elasticity problem in a pure displacement formulation, where a lower order finite element method is studied which is optimal order accurate and robust with respect to the Poisson ratio parameter. Another example is a penalty method for incompressible viscous flows. In this case, we show that barycenter refined meshes prompt a "first penalize, then discretize" approach, avoiding locking phenomena, and leading to a method with optimal convergence rates independent of the penalty parameter, and resulting in discrete systems with advantageous algebraic properties. (Received March 01, 2011)

1071-65-50 **Keith J Galvin*** (kjgalvi@clemson.edu), **Hyesuk K Lee**, **Maxim A Olshanskii** and **Leo G Rebholz**. *Analysis of a numerical method for the velocity-vorticity-helicity formulation of the Navier-Stokes equations.* Preliminary report.

We consider a splitting method for computing solutions to the NSE, based on the velocity-vorticity-helicity formulation. Numerical analysis and several numerical experiments will be given, and important open questions will be discussed. (Received February 02, 2011)

1071-65-65 **Ryan Fernandes** (rfernandes@pi.ac.ae), Department of Mathematics, The Petroleum Institute, P.O. Box 2533, Abu Dhabi, United Arab Emirates, and **Graeme Fairweather*** (gxf@ams.org), Mathematical Reviews, 416 Fourth Street, Ann Arbor, MI 48103. *An ADI extrapolated Crank-Nicolson orthogonal spline collocation method for nonlinear reaction-diffusion systems.*

A new numerical technique is presented for the solution of a class of two-component nonlinear reaction-diffusion problems in a rectangle. In this method, orthogonal spline collocation (OSC) with piecewise polynomials of degree $r \geq 3$ is used for the spatial discretization, and the time-stepping is done using an alternating direction implicit (ADI) method based on an extrapolated Crank-Nicolson OSC method. This ADI OSC method reduces the multidimensional problem to sets of independent OSC two-point boundary value problems in the coordinate directions. It is algebraically linear, with a computational cost per time step of $\mathcal{O}(\mathcal{N})$ operations where $\mathcal{N}$ is the number of unknowns. Using well-known examples of reaction-diffusion models arising in chemistry and biology, it is demonstrated numerically that the method is second-order accurate in time and of optimal accuracy in space in various norms as well as possessing superconvergence properties. (Received February 13, 2011)

1071-65-71 **Zhu Wang*** (wangzhu@vt.edu), 460 McBryde Hall, Department of Mathematics, Virginia Tech, Blacksburg, VA 24061, and **Traian Iliescu** (iliescu@vt.edu), 456 McBryde Hall, Department of Mathematics, Virginia Tech, Blacksburg, VA 24061. *Proper Orthogonal Decomposition Nonlinear Closure Models of Engineering and Geophysical Flows.*

Proper orthogonal decomposition is one of the most commonly used methods to generate reduced-order models for turbulent flows dominated by coherent structures. To balance the low computational cost required by a reduced-order model and the complexity of the targeted turbulent flows, appropriate closure modeling strategies need to be employed. We introduce novel nonlinear closure models for complex engineering and geophysical flows. The new models are supported by extensive numerical experiments such as 3D turbulent flow past a circular cylinder and the oceanic barotropic double-gyre circulation problem. We also prove rigorous error estimates for the finite element discretization of the reduced-order models. (Received February 15, 2011)

1071-65-78 **Jerry lloyd Bona**, **Hongqiu Chen**, **Ohannes Karakashian** and **Yulong Xing***, Department of Mathematics, University of Tennessee, 227 Ayres Hall, knoxville, 37996. *Conservative discontinuous Galerkin methods for the generalized Korteweg-de Vries equation.*

The Korteweg-de Vries (KdV) equation is a nonlinear mathematical model for the unidirectional propagation of waves in a variety of nonlinear, dispersive media. Recently it has attracted increasing attention as test-bed for the competition between nonlinear and dispersive effects leading to a host of analytical issues such global existence and finite time blowup, etc.

In this presentation, we construct, analyze, and numerically validate a class of conservative discontinuous Galerkin schemes for the generalized KdV equation. The schemes preserve the first two invariants (the integral and L2 norm) of the numerical approximations. We provide numerical evidence that this property imparts the approximations with beneficial attributes such as more faithful reproduction of the amplitude and phase of traveling wave solutions. (Received February 17, 2011)

1071-65-83 **Weizhang Huang*** (huang@math.ku.edu), 1460 Jayhawk Boulevard, Room 405, The University of Kansas, Lawrence, KS 66045. *Mesh adaptation for the finite element solution of heterogeneous anisotropic diffusion problems.*

Anisotropic diffusion problems arise in the various areas such as plasma physics, petroleum engineering, and image processing. For those problems standard numerical methods can produce spurious oscillations in computational solutions. A common strategy to avoid the difficulty is to employ a scheme satisfying the discrete maximum principle (DMP). For isotropic diffusion problems, a mesh satisfying the well-known non-obtuse angle condition guarantees the satisfaction of DMP by a linear finite element solution. In this talk we will show that a mesh satisfying a generalization of the non-obtuse condition will guarantee the satisfaction of DMP by the linear finite element solution for anisotropic diffusion problems. We will also present several variants of the new condition and discuss their use in developing metric tensors to account for DMP satisfaction and the combination of DMP

satisfaction and mesh adaptivity. These metric tensors are needed in the practice of anisotropic generation and adaptation. Numerical examples are given to demonstrate the features of schemes based on DMP satisfaction and mesh adaptation. (Received February 21, 2011)

1071-65-85 **Fengyan Li** and **Liwei Xu*** (xul3@rpi.edu), 301 Amos Eaton Hall, Rensselaer Polytechnic Institute, Troy, NY 12180. *Central Discontinuous Galerkin Methods for ideal MHD Equations with the Exactly Divergence-Free Magnetic Field.*

In this talk, we discuss central discontinuous Galerkin methods for the solution of ideal magnetohydrodynamic (MHD) equations. The methods are based on the original central discontinuous Galerkin methods designed for hyperbolic conservation laws on overlapping meshes, and use different discretization for magnetic induction equations. The resulting schemes carry many features of standard central discontinuous Galerkin methods such as high order accuracy and being free of exact or approximate Riemann solvers. And more importantly, the numerical magnetic field is exactly divergence-free. Such property, desired in reliable simulations of MHD equations, is achieved by first approximating the normal component of the magnetic field through discretizing induction equations on the mesh skeleton, namely, the element interfaces. And then it is followed by an element-by-element divergence-free reconstruction with the matching accuracy. Numerical examples are presented to demonstrate the high order accuracy and the robustness of the schemes. (Received February 21, 2011)

1071-65-88 **Wei Leng**, **Lili Ju*** (ju@math.sc.edu), **Max Gunzburger**, **Stephen Price** and **Todd Ringler**. *A Parallel High-Order Accurate Finite Element Nonlinear Stokes Ice-Sheet Model and Benchmark Experiments.* Preliminary report.

A parallel finite element implementation on tetrahedral grids of the nonlinear three-dimensional nonlinear Stokes model for the dynamics of ice-sheets is presented. Discretization is based on a high-order accurate scheme using the Taylor-Hood element pair. Both no-slip and sliding boundary conditions at the ice-bedrock boundary are studied. In addition, effective solvers using preconditioning techniques for the saddle-point system resulting from the discretization are discussed and implemented. We demonstrate through established ice-sheet benchmark experiments that our finite element nonlinear Stokes model performs at least as well as other published and established Stokes models in the field, and the parallel solver is shown to be efficient, robust, and scalable. (Received February 22, 2011)

1071-65-101 **Alan Demlow*** (alan.demlow@uky.edu) and **Rob Stevenson**. *Optimality of an adaptive FEM for controlling L_2 errors.*

We prove quasi-optimality of an adaptive finite element methods for controlling the L_2 error in elliptic problems instead of the usual energy error. In our presentation we explain how the L_2 case differs from the energy case, and also make an excursion into techniques of a priori error analysis. (Received February 25, 2011)

1071-65-102 **Alan Demlow*** (alan.demlow@uky.edu). *Recent progress in a posteriori estimation of pointwise errors in FEM.*

In this talk we will survey some recent results concerning a posteriori estimation of maximum or pointwise errors in finite element methods for elliptic problems. (Received February 25, 2011)

1071-65-105 **Jeffrey Ovall*** (jovall@ms.uky.edu), Patterson Office Tower 761, Department of Mathematics, University of Kentucky, Lexington, KY 40506, and **Randolph Bank** and **Luka Grubisic**. *A framework for robust eigenvalue error estimation and ritz value convergence enhancement.*

We present a general framework for the a posteriori estimation and enhancement of error in eigenvalue/eigenvector computations for symmetric and elliptic eigenvalue problems, and provide detailed analysis of a specific and important example within this framework—finite element methods with continuous, affine elements. A distinguishing feature of the proposed approach is that it provides provably efficient and reliable error estimation under very realistic assumptions, not only for single, simple eigenvalues, but also for clusters which may contain degenerate eigenvalues. We reduce the study of the eigenvalue/eigenvector error estimators to the study of associated boundary value problems, and make use of the wealth of knowledge available for such problems. Our choice of *a posteriori* error estimator, computed using hierarchical bases, very naturally offers a means not only for estimating error in eigenvalue/eigenvector computations, but also cheaply accelerating the convergence of these computations—sometimes with convergence rates which are nearly twice that of the unaccelerated approximations. (Received February 25, 2011)

1071-65-120 **Hao Gao** and **Hongkai Zhao***, Department of Mathematics, University of California, Irvine, CA 92697. *An efficient multi-level method for radiative transport equation with applications to optical imaging.*

We present an efficient algorithm for solving radiative transport equation (RTE) which is a golden standard for modeling photon migration in tissue. RTE is proposed in phase space which includes both spatial and angular variables. Moreover, the scattering term coupled particle transport in all directions together. We design a multi-level algorithm in both space and angle combined with appropriate discretization. Our algorithm can deal with multiple scattering and forward peaking effectively. Convergence and error estimate analysis will be shown. Applications to optical imaging will be provided. (Received February 27, 2011)

1071-65-125 **Santtu Salmi** (santtu.salmi@jyu.fi), Jyvaskyla, Finland, and **Jari Toivanen*** (toivanen@stanford.edu), Stanford, CA. *An iterative method for pricing American options under jump-diffusion models.*

An implicit finite difference method for the linear complementarity problem (LCP) formulation of American options under jump-diffusion models leads to the solution of LCPs with full matrices at each time step. We propose an iteration which solves a sequence of LCPs with the corresponding model without jumps at each time step. As these LCPs are easier to solve and the iteration converges quickly this gives an efficient way to price American options under jump-diffusion models. (Received February 28, 2011)

1071-65-127 **Xinfeng Liu*** (xfliu@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29063, and **Qing Nie** (qnie@math.uci.edu), Department of Mathematics, University of California at Irvine, Irvine, CA 92697. *Implicit integration factor methods for stiff systems.*

Implicit integration factor (IIF) method, a class of efficient semi-implicit temporal scheme, was introduced recently for stiff reaction-diffusion equations. Advection-reaction-diffusion equations are traditionally difficult to handle numerically. For reaction-diffusion systems with both stiff reaction and diffusion terms, implicit integration factor (IIF) method and its high dimensional analog compact form (cIIF) serve as an efficient class of time-stepping methods. For nonlinear hyperbolic equations, weighted essentially non-oscillatory (WENO) methods are a class of start-of-the-art schemes with uniform high order of accuracy in smooth regions of the solution, which can also resolve the sharp gradient in accurate and essentially non-oscillatory (ENO) fashion. In this talk, IIF/cIIF is coupled with WENO by the second-order symmetric operator splitting approach to solve advection-reaction-diffusion equations. In the methods, IIF/cIIF methods treat the stiff reaction-diffusion equations, and WENO methods handle hyperbolic equations that arise from the advection part. In addition, we present a method for integrating IIF/cIIF with adaptive mesh refinement (AMR) to take advantage of the excellent stability condition for IIF/cIIF. (Received February 28, 2011)

1071-65-155 **Shuhua Zhang*** (szhang59@gmail.com), Department of Mathematics, Tianjin University of Finance and Economics, Tianjin, Peoples Rep of China. *Numerical Methods for Option Pricing and Calibration of the Extended CIR Model.*

In this talk we are concerned with finite element approximations to the evaluation of American options and DG methods for the calibration of the extended CIR model. In the first part of the talk, first, we introduce a novel practical approach to the discussed problem, which involves the exact reformulation of the original problem and the implementation of the numerical solution over a very small region, such that this algorithm is very rapid and highly accurate. Second, by means of a superapproximation and interpolation postprocessing analysis technique, here we present the sharp L^2-, L^∞-norm error estimates and the H^1-norm superconvergent estimate, respectively, for this finite element method. As a by-product, the global superconvergence result can be used to generate an efficient a posteriori error estimator. Finally, some numerical examples are provided to demonstrate our theoretical results. In the second part of the talk, the discontinuous Galerkin method is used to solve the calibration of the extended CIR model, and its superconvergence approximations are obtained. (Received March 03, 2011)

1071-65-158 **Jeffrey Ovall***, jovall@ms.uky.edu, and **Michael Holst** and **Ryan Szypowski**. *Constructing and Analyzing Non-Standard Error Estimators of Hierarchical Type.*

Given the finite element solution in an approximation space V, a posteriori error estimators of hierarchical type are based on the computation of an approximate error function in an auxiliary space W. We present an approach for constructing and analyzing non-standard error estimators of this type. A practical realization of our approach is given for second-order elliptic problems in $\mathbb{R}^3$, which may be linear or quasi-linear. The approximation space V is taken to be the usual continuous piecewise-linear functions, and the error space W

consists of continuous piecewise-cubic functions which vanish on all edges in the mesh. We provide an effectivity analysis under realistic assumptions, which clearly shows the dependence/independence of constants on the data—in particular, all constants are independent of the forcing term and boundary data. We also argue that the stiffness matrix associated with computations in W is spectrally-equivalent to its diagonal, and therefore simple to solve inexpensively. A series of numerical experiments demonstrate the effectivity of the error estimator, and its utility as a guide for adaptive refinement. In many cases, comparisons will be made with common error estimators of both residual and gradient-recovery types. (Received March 03, 2011)

1071-65-166 **Michael Holst** (mholst@math.ucsd.edu), 9500 Gilman Drive, Dept. 0112, La Jolla, CA 92093, **Ryan Szypowski** (rszypows@math.ucsd.edu), 9500 Gilman Drive, Dept. 0112, La Jolla, CA 92093, and **Yunrong Zhu*** (zhu@math.ucsd.edu), 9500 Gilman Drive, Dept. 0112, La jolla, CA 92093. *Convergence of Adaptive Finite Element Methods with Inexact Solvers for Poisson-Boltzmann Equations.* Preliminary report.

In this talk, we consider the design of practical adaptive multilevel finite element methods for the nonlinear Poisson-Boltzmann equation (PBE). At each refinement level, the nonlinear system of equations is solved inexactly by Newton/multilevel methods. Under certain assumptions of the inexact solver, we are able to show that the adaptive algorithm still satisfies the contraction property between two successive refinements. The convergence and accuracy of the overall AFEM algorithm is also illustrated by numerical experiments. (Received March 03, 2011)

1071-65-178 **Sum Chow*** (schow@math.byu.edu), Dept of Mathematics, Brigham Young University, Provo, UT 84602, and **Warren Crutcher** (warrencrutcher@gmail.com), Provo, 84602. *Finite element approximations of glacier flows with sliding.* Preliminary report.

The steady flow of glaciers is typically represented by a nonlinear partial differential equation with gradient nonlinearity. Sliding is an important mechanism in glacier flows but are difficult to model. In the study we examined extension of the model proposed by Calvo et al and investigated an alternative formulation using Bingham like model. We will discuss the use of finite element method to solve the problems. (Received March 04, 2011)

1071-65-205 **Kai Huang*** (khuang@fiu.edu), Department of Mathematics, Florida International University, Miami, FL 33199. *Numerical Pricing of Bond Options under the Quadratic Interest Rate Model.* Preliminary report.

We have developed and implemented finite difference methods and a front-fixing finite element method for pricing of bond options under the quadratic interest rate model. Numerical examples will be presented to examine our methods and to compare the quadratic interest rate model with the Hull-white model and the extended CIR model. (Received March 06, 2011)

1071-65-227 **Junping Wang*** (jwang@nsf.gov), 4201 Wilson Boulevard, Arlington, VA 22230. *Maximum Principle for Finite Element Methods.* Preliminary report.

This talk will present some recent results for maximum principle for numerical approximations of second order elliptic PDEs (linear and nonlinear) arising from Galerkin finite element methods and mixed finite element methods. (Received March 07, 2011)

1071-65-237 **Jichun Li*** (jichun@unlv.nevada.edu), Dept of Mathematical Sciences, University of Nevada Las Vegas, Las Vegas, NV 89154-4020, **Yunqing Huang** (huangyq@xtu.edu.cn), President's Office, Xiangtan University, Xiangtan, Hunan 411105, Peoples Rep of China, and **Wei Yang** (yangweixtu@126.com), College of Mathematical Sciences, Xiangtan University, Xiangtan, Hunan 411105, Peoples Rep of China. *Interior penalty DG methods for Maxwell's equations in dispersive media.*

In this talk, we will introduce several interior penalty discontinuous Galerkin methods for solving the time-dependent Maxwell's equations in dispersive media. The model is described by a vector integro-differential equation. Numerical stability and error estimates will be discussed. Numerical results supporting the analysis will be presented. (Received March 07, 2011)

1071-65-241 **Gerard Awanou***, Northern Illinois University, Department of Mathematical Sciences, Watson 320, Dekalb, IL 60115. *Good numerical solutions of fully nonlinear elliptic equations.* Preliminary report.

While the theory of second order fully nonlinear equations has received considerable attention, there is a paucity of numerical methods capable of capturing singular solutions for these equations. We introduce an iterative method on which numerical methods can be based. We discuss convergence to the viscosity solution for the

Pucci equation and illustrate the performance of the approach with numerical experiments for both the Monge-Ampere and Pucci equations. (Received March 07, 2011)

1071-65-248 **Hieu Nguyen*** (htrnguyen@ucdavis.edu), htrnguyen@ucdavis.edu, and **Randolph E. Bank**, rbank@ucsd.edu. *A New Approach to p-Adaptive Finite Element Method.*

In this talk, we propose a new approach to the p-version of adaptive finite element method. Our work is characterized by the use of nodal basis functions and a posteriori error estimates based on derivatives recovery technique. The special nodal basis functions defined for transition elements allow us to accommodate elements of different degrees while avoiding hanging nodes and maintaining the continuity of the finite element space. Our error estimates are also very attractive as they are robust and independent of the PDE problem. Numerical results will be provided to show the efficiency of our approach. (Received March 08, 2011)

1071-65-255 **Long Chen***, Department of Mathematics, University of California at Irvine, Irvine, CA 92697. *Adaptive Finite Element Methods for H(curl) and H(div) Problems.*

We design adaptive finite element methods (AFEMs) for variational problems posed in the Hilbert spaces H(div) and H(curl) in two and three dimensions. The main difficulty is the large null space of curl or div operators and we solve it by using discrete regular decompositions and a novel stable and local projection operator. As a result, we obtain convergence and optimal complexity of our adaptive algorithms. (Received March 08, 2011)

1071-65-263 **Jeffrey M Connors*** (connors4@llnl.gov), Lawrence Livermore National Laboratory, 7000 East Avenue, L-561, Livermore, CA 94551, and **William J Layton**. *Large eddy simulation for fluid-fluid interaction: evolve, filter and relax.*

Motivated by atmosphere-ocean interaction, a method of performing large eddy simulations of two fluids coupled by boundary conditions at their interface is examined. A full discretization is performed for the Navier-Stokes equations and the computations are broken into three stages for each time step. The evolution step is performed followed by a filtering step. Then a relaxation parameter is calculated and the update step is defined by taking a convex combination of the filtered and unfiltered solutions. The method is made parameter free by introducing an explicit relationship for the relaxation parameter at each time step in terms of the filtered and unfiltered solution. This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. (Received March 08, 2011)

1071-65-267 **Atife Caglar*** (caglara@uwgb.edu), 2420 Nicolet Dr , Department of NAS, ES 317, Green BAy, WI 54311. *Convergence Analysis of the NS-αModel.*

In a recent published work we considered the NS-α model as an approximation of turbulent flows under non-periodic boundary conditions. We proved global existence and uniqueness of weak solutions of the particular model. Further, we give a semi discretization of the model using the finite element approximations and proved convergence of the model. In this presentation we describe the ideas behind proving convergence of the method to the continuous NS-α solution as $h \to 0$ for a constant α. (Received March 08, 2011)

1071-65-271 **Manny A. Macatangay*** (mmacatangay@nvenergy.com), Resource Optimization Department, NV Energy Inc., 6226 West Sahara Avenue M/S 26, Las Vegas, NV 89146, **Alebachew Yimer** (ayimer@nvenergy.com), Resource Optimization Department, NV Energy Inc., 6226 West Sahara Avenue M/S 26, Las Vegas, NV 89146, and **Denis Wang** (gwang@nvenergy.com), Resource Optimization Department, NV Energy Inc., 6226 West Sahara Avenue M/S 26, Las Vegas, NV 89146. *Jump diffusion price modeling in hedge strategy analysis.* Preliminary report.

Draft abstract: The analysis of alternative hedge strategies depends on price simulations determining the cost distribution that the hedger seeks to control. Alternative strategies for hedging are determined through an optimization of the mix and structure of financial instruments procured over time and in accordance with corporate risk metrics, financial constraints, or hedge program budgets. The parameters of a jump diffusion price model are calibrated for various historical periods potentially encompassing different phases in industry market fundamentals, such as price spikes or collapses, structural shifts in the supply or demand regime, and so-called harvesting or investing phases. Cost distributions resulting from the calibrations are compared in order to find a reasonable approach to price modeling and ultimately to evaluate the economic consequences of alternative hedge strategies. The views are the authors' and do not represent the official views of NV Energy Inc. (Received March 08, 2011)

1071-65-287 **Pengtao Sun*** (pengtao.sun@unlv.edu), 4505 Maryland Parkway, Las Vegas, NV 89154. *MODELING STUDIES AND EFFICIENT NUMERICAL METHODS FOR PROTON EXCHANGE MEMBRANE FUEL CELL.*

In this paper, a three-dimensional, nonisothermal, multiphysics, two-phase steady state transport model and its efficient numerical methods are systematically studied for a full proton exchange membrane fuel cell (PEMFC) for the first time, in the sense of efficiency and accuracy. The conservation equations of mass, momentum, species, charge and energy are fully addressed in view of the nonisothermality and multiphase feature in PEMFC model. In addition, we present some new formulations for species equations in the interests of interactions among the species from an accurate numerical discretization's point of view. In a framework of the combined finite element-upwind finite volume method, some efficient numerical methods are developed in terms of Kirchhoff transformation in order to achieve fast and convergent numerical simulation for the studied PEMFC model. Threedimensional numerical simulations demonstrate that the convergent physical solutions can be attained within 80 steps, in contrast to the oscillating and nonconvergent nonlinear iterations conducted by commercial flow solvers or in-house code with standard finite element/volume methods. The results of numerical convergence tests verify the efficiency and accuracy of our numerical algorithms and techniques. (Received March 09, 2011)

70 ► Mechanics of particles and systems

1071-70-4 **Tai-Ping Liu*** (liu@math.stanford.edu), Department of Mathematics, 450 Serra Mall Stanford, Stanford, CA 94305. *Hilbert Sixth Problem.*

Abstract: When Hilbert formulated his Sixth Problem, he had in mind mostly the relationship of the kinetic theory with Newtonian interacting particle systems and with the fluid dynamics. The relationship of the Boltzmann equation in the kinetic theory with the Newtonian interacting particle systems has been largely unresolved mathematically. There are more than one fundamental issues on this part of Hilbert Sixth Problem. The celebrated work of Lanford (1975) represents an important, but preliminary, step in this direction. The relationship of the Boltzmann equation with the fluid dynamics is a very rich area. There is the well-known series of works on the convergence of the Diperna-Lions weak Boltzmann solutions to the Leray weak solution of incompressible Navier-Stokes equations. The study of the shock waves starting from the kinetic theory has been initiated in recent years. The kinetic theory is closer to the first principle in physics, particularly on the formulation of the boundary condition. There is now a field of Modern Fluid Dynamics resulting from the study of the kinetic theory. This talk aims at exploring these and other issues, and highlighting the major open problem. (Received March 09, 2011)

74 ► Mechanics of deformable solids

1071-74-173 **Qiang Du*** (qdu@math.psu.edu), Department of Mathematics, Penn State University, University Park, PA 16802. *Analysis and approximations of nonlocal balance laws and peridynamics.*

We discuss some nonlocal balance laws and in particular the peridynamic models. A vector calculus for nonlocal operators is shown to give a fundation to pose such nonlocal models with reduced regularity requirements. We address some basic well-posedness issues and explore connections with local models. We also study finite dimensional approximations of nonlocal models, such as convergence, a priori and a posteriori error analysis and conditioning of nonlocal stiffness matrices. This talk is based on:

1 Q. Du and K. Zhou, Mathematical analysis for the peridynamics nonlocal continuum theory, ES-IAM: M2AN, 2011.

2 K. Zhou and Q. Du, Mathematical and numerical analysis of the linear peridynamic models with nonlocal boundary conditions, SINUM, 2010.

3 Q. Du, M. Gunzburger R. Lehoucq and K. Zhou, A nonlocal vector calculus, nonlocal volume-constrained problems, and nonlocal balance laws., Sandia Report, 2010.

4 Q. Du, M. Gunzburger, R. Lehoucq and K. Zhou, Analysis and approximation of nonlocal diffusion problems with volume constraints, Sandia Report, 2011.

5 Q. Du, L. Ju, L. Tian and K. Zhou, A posteriori error analysis of finite element method for nonlocal diffusion problems and peridynamic models, preprint, 2011.

(Received March 03, 2011)

76 ► Fluid mechanics

1071-76-72 **Hyesuk Lee*** (hklee@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634. *The Arbitrary Lagrangian Eulerian method for unsteady non-Newtonian flows in a moving domain.*

We present numerical methods for non-Newtonian fluid flows in a moving domain. Such problems arise in modeling the interaction of fluid flows with an elastic medium, which is of great interest in industry and biological area. The moving domain problem is solved by the Arbitrary Lagrangian Eulerian method (ALE), where an one-to-one mapping between a reference domain and a physical domain is introduced. The variational formulations by ALE and finite element error estimates will be considered. Some numerical results will be also presented. (Received February 15, 2011)

1071-76-87 **Hisashi Okamoto*** (okamoto@kurims.kyoto-u.ac.jp), Kyoto, 606-8502, Japan. *Blow-up problems in the strained vorticity dynamics and critical exponents.* Preliminary report.

Two partial differential equations are studied from the view-point of critical exponents. They are equations for a scalar unknown of a single spatial variable, and produce self-similar solutions of the Navier-Stokes equation. The global existence and blow-up are examined for them, and the critical exponent separating them is determined. (Received March 03, 2011)

1071-76-109 **Elena Nikonova***, nikonova@unlv.nevada.edu, **Monika Neda**, monika.neda@unlv.edu, and **David Hannasch** and **Shipra De**. *Finite element analysis and computations of regularized Navier-Stokes equations by time relaxation.* Preliminary report.

We present a numerical study based on continuous finite element analysis for a time relaxation regularization of Navier-Stokes equations. This regularization is based on filtering and deconvolution methodology. The convergence analysis is extented to the fully discretized filter and deconvolution algorithm. The Aubin-Nitche lift technique is proved too. Thus, optimal error estimates in L2 and H1 norms are derived, and followed by their computational verification. Also, computational results of the vortex street are presented for the benchmark problem, the two-dimensional cylinder flow problem. (Received February 25, 2011)

1071-76-138 **Tae-Yeon Kim** and **Monika Neda***, monika.neda@unlv.edu, and **Leo Rebholz** and **Eliot Fried**. *A numerical study of regularized Navier-Stokes equations.*

We present a numerical study of the Navier-Stokes-$\alpha\beta$ model, which is a recently proposed variation of the NS-α model that attempts to recapture scales lost through over-regularization. A similarity theory for the new model will be presented, then study of an unconditionally stable, optimally accurate, and efficient finite element implementation of it. Also, numerical experiments which show the advantages of Navier-Stokes-$\alpha\beta$ over NS-α will be presented. (Received March 01, 2011)

1071-76-157 **Nicholas E. Wilson*** (newilso@clemson.edu). *A Leray-Deconvolution Model of Turbulence for the Magnetohydrodynamics Equations.* Preliminary report.

It has recently been shown that for the Leray-α regularization of the Navier-Stokes equations (NSE) one can improve accuracy by adding deconvolution. The solutions of the Leray-deconvolution model are known to converge (modulo a subsequence) to the solution of the NSE when the deconvolution parameter N is fixed and α goes to zero and when α is fixed and N goes to infinity. We study a high accuracy Leray-deconvolution model for the incompressible magnetohydrodynamics equations (MHD). The model is shown to be well posed and to exhibit limiting behavior analogous to that of the Leray-deconvolution model for the NSE. Additionally, we study a numerical scheme for the model based on an extrapolated Crank-Nicolson method. We show the numerical scheme converges to the solution of the MHD equations and verify shown convergence rates with numerical experiments. Lastly, we test the developed numerical scheme on the Orszag-Tang vortex problem. (Received March 03, 2011)

1071-76-179 **Xiaoming Wang***, Department of Mathematics, Florida State University, Tallahassee, FL 32306. *Long time behavior of the randomly forced barotropic quasi-geostrophic equation.* Preliminary report.

We present an explanation of the recently observed statistically zonal flows within a barotropic quasi-geostrophic equation under small scale random forcing due to Srinivasan and Young. Our explanation consists of two parts: (1) the uniqueness of invariant measure; and (2) the zonal invariance of this invariant measure. (Received March 04, 2011)

1071-76-210 **Igor Kukavica**, University of Southern California, Los Angeles, CA 90089, and **Vlad Vicol*** (vicol@math.uchicago.edu), University of Chicago, Chicago, IL 60637. *On the local well-posedness of the Prandtl boundary layer equations.*

We address the local well-posedness of the Prandtl boundary layer equations. Using a new change of variables we allow for more general data than previously considered, that is, we require the matching at the top of the boundary layer to be at a polynomial rather than exponential rate. The proof is direct, via analytic energy estimates in the tangential variables. (Received March 06, 2011)

1071-76-244 **Robert L. Pego**, Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213, and **Shu-Ming Sun*** (sun@math.vt.edu), Department of Mathematics, Virginia Tech, Blacksburg, VA 24061. *Asymptotic linear stability of solitary water waves.*

The talk will discuss the recent result on asymptotic linear stability of two-dimensional solitary waves on water. It is assumed that the fluid is bounded by a free surface and a rigid horizontal bottom. The solitary wave is moving under the gravity and the surface tension is ignored. It was known that the fully nonlinear Euler equations have a solitary-wave solution. In this talk, we will show that the linear operator arising from linearizing the Euler equations around the solitary-wave solution has no spectrum points lying on the right half of the complex plane. Moreover, the solutions of the linearized equations decay at an exponential rate in an energy norm with an exponential weight, under the condition that the solutions have no component in the two-dimensional neutral-mode space arising from the solitary waves. (Received March 07, 2011)

82 ► Statistical mechanics, structure of matter

1071-82-184 **David B Johnson**, 4600 Sunset Ave, Indianapolis, IN 46208, and **Gonzalo E Ordonez***, 4600 Sunset Ave, Indianapolis, IN 46208. *Quantum Diffusion-Limited Aggregation.* Preliminary report.

The motivation for this talk is the following question: what is the role played by quantum mechanics in the formation of complex structures? We will discuss recent work on this subject. We have considered the formation of structures with fractal geometry by the aggregation of randomly moving particles. This process has been studied by many authors using the classical random walk to model the motion of the aggregating particles. In order to include quantum effects, we have replaced the classical random walk by the quantum motion described by Schrodinger's equation. Our numerical results indicate that the motion of particles governed by Schrodinger's equation, tied to periodic collapse of the wave function also generates fractal structures with fractal dimension similar to that of the classically generated structures. Our results show that the quantum process is much more efficient at building fractals than the classical process. It is an exciting possibility that this type of fractal structure might be observed experimentally in the future. (Received March 04, 2011)

90 ► Operations research, mathematical programming

1071-90-17 **Shafiu Jibrin*** (Shafiu.Jibrin@nau.edu), Department of Mathematics & Statistics, Northern Arizona University, Flagstaff, AZ 86011-5717, and **Jim Swift**. *Constraint Consensus Methods for Finding Strictly Feasible Points of Linear Matrix Inequalities.*

We apply two of John Chinneck's constraint consensus methods to handle linear matrix inequalities. The original and DBmax methods find points near the feasible region defined by general nonlinear constraints. We modify and combine these methods to give four different new methods in a way that extends the length of the consensus vectors to find points in the interior of the feasible region. We present results of numerical experiments that compare the four methods. We note that our methods are applicable to other constraints including non-convex types provided the gradients and the crossing points are computable. (Received December 01, 2010)

1071-90-132 **Zhen Liu*** (zliu@mst.edu), 600 W. 14th Street, Rolla, MO 65409. *Energy Portfolio Investment with Delayed Entry Decisions.*

Climate change is recognized as the major environmental problem faced by the world. Of most concern factors is the increase in carbon dioxide levels due to emissions from fossil fuel combustion. Therefore construction of a greener power plant, which is subject to huge initial capital investment, is crucial to reducing carbon dioxide emission. The decrease in coal reserves is also pushing power plant to generate more new green energy. Due to the uncertainties in electricity prices, alternative green energy prices, and the cost of carbon dioxide emissions, an

energy portfolio should be formed to diversify the risks faced by generators. We formulate the decision-making as an optimization problem to maximize long-term profit through stochastic control and up-wind finite difference method, and solve the following problems: (1) the optimal time to build a new alternative green energy power generating plant, and (2) the optimal dispatch from the existing coal plant and the new plant. (Received March 01, 2011)

91 ► Game theory, economics, social and behavioral sciences

1071-91-5 **Siamak Ardekani*** (ardekani@uta.edu), Civil Engineering Department, The University of Texas at Arlington, UTA Box 19308, Arlington, TX 76019, and **Mostafa Ghandehari**. *A Blackjack Pseudo Card Counting System with Simulation-Based Comparisons.* Preliminary report.

A pseudo card counting system is presented for the game of blackjack, with comparison made to a conventional counting system. The comparison is based on a simulation of the game assuming an initial 200 dollars bank at a 5 dollars minimum table. The basis of comparison is the return on investment(ROI) for 100 simulation data. Statistical tests of hypothesis are made to see if the number of players at the table or the number of card decks in the shoe has a significant effect on the ROI. (Received June 15, 2010)

92 ► Biology and other natural sciences

1071-92-3 **Elizabeth S Allman*** (e,allman@alaska.edu), PO Box 756660, Fairbanks, AK 99709. *Evolutionary trees and phylogenetics: an algebraic perspective.*

Phylogenetics is the branch of biology concerned with inferring evolutionary relationships between currently extant species. For instance, are humans more closely related to chimpanzees or to gorillas on an evolutionary tree? A typical phylogenetic analysis from molecular data might consist of sampling gene sequences from a number of species, aligning them, and performing a statistical analysis to choose a tree that best displays the evolutionary relationships of the taxa.

While phylogenetic analyses are usually undertaken with standard statistical approaches such as Maximum Likelihood or MCMC in a Bayesian framework, these require formulating a probabilistic model of the DNA substitution process on a tree. Because many of these models are naturally given by polynomial parameterizations, by considering the algebraic varieties these maps define, the viewpoint of algebraic geometry can be used to gain theoretical understanding of the limits and advantages of such models.

This talk begins with an introduction to phylogenetics, and then addresses how algebraic techniques are being used to advance the theoretical end of this field. Surprising connections will be made between seemingly disparate areas of mathematics. (Received October 24, 2010)

1071-92-9 **Sorin Mitran*** (mitran@unc.edu), CB3250, Chapel Hill, NC 27599-3250. *When do cilia stop beating?*

Ciliar propulsion is an ubiquitous fluid transport mechanism in the animal kingdom. The effectiveness of the transport depends both on the internal force-generating mechanism and the properties of the surrounding fluid. In this work a computational fluid-structure interaction model is used to investigate how fluid transport rates vary when changing the viscoelastic properties of the medium and the cilium axoneme structure. (Received October 30, 2010)

1071-92-12 **Doron Levy*** (dlevy@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *Mathematical Models of Phototaxis.*

Microbes live in environments that are often limiting for growth. They have evolved sophisticated mechanisms to sense changes in environmental parameters such as light and nutrients, after which they swim or crawl into optimal conditions. This phenomenon is known as "chemotaxis" or "phototaxis." Using time-lapse video microscopy we have monitored the movement of phototactic bacteria, i.e., bacteria that move towards light. These movies suggest that single cells are able to move directionally but at the same time, the group dynamics is equally important. In this talk we will present our recent results on mathematical models of phototaxis. These models range from deterministic to stochastic and from particle to fluid models. We will discuss the models,

their simulations, and our theoretical results. This is a joint work with Devaki Bhaya, Amanda Galante, Tiago Requeijo, and Seung-Yeal Ha. (Received November 10, 2010)

1071-92-14 **Dina Miqdadi*** (dina.miqdadi@mavs.uta.edu), Department of Bioengineering, Univ. of Texas at Arlington, Arlington, TX 76019, and **Mostafa Ghandehari**. *A Discrete Optimal Control in Pharmacokinetics.* Preliminary report.

A discrete compartmental model of pharmacokinetics is given. An optimal control problem is formulated to minimize toxicity or cost of medications. Concepts from linear algebra for example eigenvalues, eigenvectors and diagonalization of matrices is used to analyze the problem. Examples of two compartmental medications for local anesthetics, congested heart failure and bipolar disorder is given. (Received November 16, 2010)

1071-92-94 **Lei Zhang*** (zhangl4@uci.edu) and **Qing Nie** (qnie@uci.edu). *Regeneration and Noise Attenuation During Development.*

During development and regeneration of a biological system, different types of cells are organized in a precise spatial pattern to achieve different biological functions. To establish a desirable spatial arrangement of various cells, such as stem cells and terminated differentiated cells, the biological host has to utilize many biological processes including diffusible molecules, feedback regulations on cell lineages, and growth. In this talk, we study how interaction among multiple morphogens and their regulations on cell differentiation capability can robustly control stability of regeneration. We also investigate the underlying mechanisms that attenuate spatial and temporal noises in both extra and intra-cellular spaces to enable formation of distinct regions with sharp boundaries consisting different cell types. In particular, we will investigate two biology systems: regeneration of colonic crypt and development of zebrafish hindbrain, using stochastic PDE models and simulations with moving boundaries. (Received February 23, 2011)

94 ► Information and communication, circuits

1071-94-114 **Dima Grigoriev** and **Vladimir Shpilrain***, Department of Mathematics, The City College of New York, New York, NY 10031. *Cryptography without one-way functions.*

We show that some problems in cryptography can be solved without using one-way functions. The latter are usually regarded as a central concept of cryptography, but the very existence of one-way functions depends on difficult conjectures in complexity theory, most notably on the notorious "$P \neq NP$" conjecture. This is why cryptographic primitives that do not employ one-way functions are often called "unconditionally secure". Here we suggest protocols for secure computation of the sum, product, and some other functions of two or more elements of an arbitrary constructible ring, without using any one-way functions. A new input that we offer here is that, in contrast with other proposals, we conceal "intermediate results" of a computation. For example, when we compute the sum of k numbers, only the final result is known to (one of) the parties; partial sums are not known to anybody. Other applications of our method include voting/rating over insecure channels and a rather elegant and efficient solution of the "two millionaires problem". We also propose a secret sharing scheme where an advantage over Shamir's and other known secret sharing schemes is that nobody, including the dealer, ends up knowing the shares (of the secret) owned by any particular player. (Received February 26, 2011)

1071-94-133 **Alexander W. Dent*** (a.dent@rhul.ac.uk), Information Security Group, Royal Holloway, University of London, Egham, Surrey TW20 0PA, England. *Reviewing Computational Papers in Cryptography Conferences.* Preliminary report.

This non-techincal talk discusses the common problems encountered when reviewing computational papers that have been submitted to cryptographic conferences. The talk aims to bridge the gap between the tools and culture of computational theory authors and the demands of cryptographic conferences (and vice versa) by discussing the five common "mistakes" that are often seen by cryptographic referees tasked with reviewing with computational papers. (Received March 01, 2011)

1071-94-135 **Wittawat Kositwattanarerk*** (wkositw@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634, and **Gretchen L. Matthews** (gmatthe@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634. *Iterative error correction for codes on graphs.*

Coding theory is the study of how information can be transmitted efficiently and reliably. The usual practice involves encoding data as a string of code symbols where the structure of the code allows detection and correction of errors. Iterative decoding algorithms are a recently developed class of graph-based algorithms that perform local decoding iteratively. These modern algorithms are extremely fast and are capable of correcting more errors

than guaranteed by the classical minimum distance of the code. Nonetheless, since the algorithms are local, they may yield a noncodeword output called a pseudocodeword. In this talk, we discuss some properties and characterizations of the graph cover pseudocodewords. (Received March 01, 2011)

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