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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
1070	April 9–10, 2011	Worcester, MA	EXPIRED	Vol 32, No. 3
1071	April 30–May 1, 2011	Las Vegas, NV	EXPIRED	Vol 32, No. 3
1072	September 10–11, 2011	Ithaca, NY	July 5	Vol 32, No. 4
1073	September 24–25, 2011	Winston-Salem, NC	August 2	Vol 32, No. 4
1074	October 14–16, 2011	Lincoln, NE	August 23	Vol 32, No. 4
1075	October 22–23, 2011	Salt Lake City, UT	August 30	Vol 32, No. 4
1076	November 29–December 3, 2011	Port Elizabeth, South Africa	TBA	Vol N, No. A
1077	January 4–7, 2012	Boston, MA	September 22	Vol 33, No. 1

STATESBORO, GA, March 12–13, 2011

Abstracts of the 1068th Meeting.

00 ► General

1068-00-202 **James Wright Scurry*** (jscurry3@math.gatech.edu). *A Characterization of Two-Weight Inequalities for a Vector-Valued Operator.*

We give a characterization of the two-weight inequality for a simple vector-valued operator. Special cases of our result have been considered before in the form of the weighted Carleson embedding theorem, the dyadic positive operators of Nazarov, Treil, and Volberg in the square integrable case, and Lacey, Sawyer, Uriarte-Tuero in the L^p case. The main technique of this paper is a Sawyer-style argument and the characterization is for $1 < p < \infty$. We are unaware of instances where this operator has been given attention in the two-weight setting before. (Received January 18, 2011)

1068-00-340 **Xiangyang Tang*** (xiangyang.tang@emory.edu), WCI suite C-5018, 1701 Uppergate Drive, Atlanta, GA 30322, and **Yi Yang** and **Shaojie Tang**. *Noise characteristics of x-ray tube and grating based phase CT over spatial resolution.*

As an emerging imaging modality for preclinical/translational applications, the x-ray tube and grating-based phase CT has seen increasing research activity recently. By providing a visualization of object's refraction distribution, the x-ray tube and grating-based phase CT is expected to provide a higher subject contrast in comparison to the conventional attenuation CT, since the refractive coefficient used for imaging with the former is substantially larger than that for imaging with the latter. The projection of the derivative refraction coefficient is detected in data acquisition. Thus, the well-known ramp filter in the filtered backprojection image reconstruction can be replaced by the finite Hilbert filter that is much more tractable in noise. With an analytic analysis and simulation-based experimental evaluation, we quantitatively describe the noise property of x-ray tube and grating based phase CT and its comparison with that of the conventional attenuation CT over exposures and detector cell size. In addition, given detector size, we will compare their spatial resolution. In such a way, the potential contrast-to-noise ratio of the phase CT and its advantages over the conventional attenuation CT for the preclinical/translational applications can be fully characterized. (Received January 20, 2011)

03 ► Mathematical logic and foundations

1068-03-153 **Fred Galvin** and **Marion Scheepers*** (mscheepe@boisestate.edu), Department of Mathematics, 1910 University Drive, Boise, ID 83725. *Borel's Conjecture and Topological groups.* Preliminary report.

We present, in the context of topological groups, consistency results regarding a generalization of Borel's Conjecture. (Received January 17, 2011)

05 ► Combinatorics

1068-05-10 **Suil O*** (suilo2@math.uiuc.edu), 409 W. Green Street, Urbana, IL 61801, and **Sebastian Cioaba** and **Douglas B West**. *Usage of Balloons in Regular Graphs.* Preliminary report.

Petersen proved that every cubic graph without cut-edges has a perfect matching, but some graphs with cut-edges have no perfect matching. The smallest cubic graph with no perfect matching belongs to a general family applicable to many problems on connected d-regular graphs with n vertices.These include the smallest matching number for such graphs and a relationship between the eigenvalues and the matching number. In addition to these results, we present new results involving this family and the Chinese Postman Problem and a relationship between eigenvalues and edge-connectivity in regular graphs. (Received December 14, 2010)

1068-05-18 **John T. Hird*** (jthird@ncsu.edu), **Naihuan Jing** and **Ernest Stitzinger**. *Codes and shifted codes of partitions.*

The Bernstein operators are a special set of vertex operators that can generate the Schur functions. We demonstrate several combinatorial proofs of the action of the Bernstein operators on Schur functions. We then show the analogous results and combinatorial objects for Schur Q-functions. (Received November 22, 2010)

1068-05-21 **Andrew Vince***, University of Florida, Department of Mathematics, 358 Little Hall, PO Box 118105, Gainesville, FL 32611-8105, and **Meera Sitharam** and **Miklos Bona**. *Counting Tree Orbits Under Permutation Group Action - An Application to Viral Shell Assembly.*

Combinatorial methods (permutation groups, Möbius inversion, generating functions) are used to answer questions about the assembly of icosahedral viral shells. The main combinatorial result is the following. If G is a finite group acting on a finite set X, then there is a natural induced action of G on the set T_X of trees whose leaves are bijectively labeled by the elements of X. When G acts freely on X (each element has trivial stabilizer), a formula is obtained for the number of orbits of each size in the action of G on T_X. (Received December 08, 2010)

1068-05-26 **Bruce E Sagan*** (sagan@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824-1027, and **Robert Willenbring** (willenb4@msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824-1027. *Discrete Morse Theory and Generalized Factor Order.* Preliminary report.

We will begin with an introduction to Robin Forman's Discrete Morse Theory (DMT). In particular, we will discuss applying this method to the order complex of a poset as has been done by Babson and Hersh.

Factor order is the partial order on words over a given alphabet which has $u \leq w$ if $w = xuy$ for words x and y, i.e., u is a factor of w. Björner found the homotopy type and thus also the Möbius function for factor order. We show how DMT can be used to rederive this result in such a way as to explain the various concepts he defines to state his formula. This approach also permits us to find an analogue of Björner's theorem in a more general setting. (Received December 22, 2010)

1068-05-34 **Elmar Teufl** (elmar.teufl@uni-tuebingen.de), Mathematisches Institut, Universität Tübingen, Auf der Morgenstelle 10, 72076 Tübingen, Germany, and **Stephan Wagner*** (swagner@sun.ac.za), Department of Mathematical Sciences, Stellenbosch University, Private Bag X1, Stellenbosch, 7602, South Africa. *Determinant identities, electrical networks, and enumeration of spanning trees on lattices.*

We make use of classical results in linear algebra that can be traced back to Sylvester's days to study the minors of Laplace matrices of graphs. It is shown how every minor of a Laplace matrix can be written in terms of those minors that are obtained by deleting two rows and the corresponding columns. Two applications of this interesting fact are presented:

- The determinant identity can be used to solve a problem in the theory of electrical networks: given the effective resistances in such a network, how can the original resistances be reconstructed?
- As another consequence, we obtain a novel approach to the enumeration of spanning trees. This method is applied to a problem from statistical physics: the enumeration of spanning trees on translation-invariant and self-similar lattices.

(Received December 23, 2010)

1068-05-35 **Ralph J. Faudree**, **Ronald J. Gould*** (rg@mathcs.emory.edu) 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. Here 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 December 28, 2010)

1068-05-67 **Patrick Allen**, **Bruce M Landman*** (landman@westga.edu) and **Holly Meeks**. *New Bounds on van der Waerden-type Numbers for Generalized 3-term Arithmetic Progressions.* Preliminary report.

Let a and b be positive integers, with $a \leq b$. An (a, b)-triple is a set of positive integers $\{x, y, z\}$ such that $y = ax + d$ and $z = bx + 2d$ for some positive integer d. Define $T(a, b; r)$ to be the least positive integer such that every r-coloring of $\{1, 2, \ldots, T(a, b; r)\}$ must contain a monochromatic (a, b)-triple. It is known that $T(a, b; 2)$ is bounded above by a fourth degree polynomial in b and a, and below by a quadratic. The main result is an improvement of the upper bound to a quadratic. We also give modest improvements to lower bounds and to the list of known values of $T(a, b; r)$. (Received January 11, 2011)

1068-05-72 **Joseph Kung**, **Xinyu Sun** and **Catherine Yan*** (cyan@math.tamu.edu), Department of Mathematics, Texas A&M University, MS STOP 3368, College Station, TX 77843-3368. *Goncarov-Type Polynomials and Applications in Combinatorics.*

In this paper we use the theory of sequences of polynomials biorthogonal to a sequence of linear operators to study combinatorial problems. In particular, we described the algebraic properties of the sequence of Goncarov polynomials and its various generalizations, which give a unified algebraic approach to several combinatorial objects, including (1) The cumulative distribution functions of the random vectors of order statistics of n independent random variables with uniform distribution on an interval; (2) general parking functions, that is, sequences $(x_1, x_2, \ldots, x_n)$ of integers whose order statistics are bounded between two given non-decreasing sequences; (3) Lattice paths that avoid certain general boundaries; and (4) The area-enumerator of lattice paths avoiding certain general boundaries. (Received January 12, 2011)

1068-05-76 **Albert Bush**, Georgia Institute of Technology, Atlanta, GA 30332, and **Yi Zhao***, Department of Math. and Stat., Georgia State University, Atlanta, GA 30303. *Minimum degree thresholds for bipartite graph tiling.*

Given a bipartite graph H and a positive integer n such that $v(H)$ divides $2n$, we define the minimum degree threshold for bipartite H-tiling, $\delta_2(n, H)$, as the smallest integer k such that every bipartite graph G with n vertices in each part and with minimum degree $\delta(G) \geq k$ contains a spanning subgraph which consists of vertex-disjoint copies of H. Zhao, Hladký-Schacht, Czygrinow-DeBiasio determined $\delta_2(n, K_{s,t})$ exactly for all $s \leq t$ and sufficiently large n. In this talk we determine $\delta_2(n, H)$, up to an additive constant, for all bipartite H and sufficiently large n. Additionally, we give a corresponding minimum degree threshold to guarantee that G has an H-tiling missing only a constant number of vertices. Our $\delta_2(n, H)$ depends on either the chromatic number $\chi(H) = 2$ or the critical chromatic number $\chi_{cr}(H)$ while the threshold for the almost perfect tiling only depends on $\chi_{cr}(H)$. These results can be viewed as bipartite analogs to the results of Kuhn and Osthus and of Shokoufandeh and Zhao for general tiling. (Received January 12, 2011)

1068-05-84 **Michael H. Albert**, **M. D. Atkinson**, **Mathilde Bouvel**, **Nik Ruškuc** and **Vincent Vatter***, vatter@ufl.edu. *Geometric grid classes of permutations.*

A geometric grid class is, roughly speaking, the set of permutations that can be drawn on a set of 45° line segments in the plane. We establish two significant properties of such permutation classes: they are partially well-ordered (i.e., they have no infinite antichains), and they have rational generating functions. (Received January 13, 2011)

1068-05-90 **Matthew Hyatt*** (m.hyatt@math.miami.edu). *Eulerian quasisymmetric functions for the type B Coxeter group and other wreath product groups.*

Eulerian quasisymmetric functions were introduced by Shareshian and Wachs in order to obtain a q-analog, involving the permutation statistics major index and excedance number, of Euler's exponential generating function formula for the Eulerian polynomials. We introduce colored Eulerian quasisymmetric functions in order to obtain a generalization of Shareshian and Wachs' formula involving colored permutation statistics of Adin, Brenti and Roichman and Foata and Han. We discuss some consequences of this formula and some of the additional properties possessed by colored Eulerian quasisymmetric functions. (Received January 14, 2011)

1068-05-101 **William T. Trotter*** (trotter@math.gatech.edu) and **Noah Streib**. *Antichains in the Product of Chains.* Preliminary report.

For a positive integer w, let $\mathbb{Z}^w$ denote the cartesian product of w copies of the integers. When $A = (a_1, a_2, \ldots, a_w)$ and $B = (b_1, b_2, \ldots, b_w)$ are elements of $\mathbb{Z}^w$, we say that A and B are k-crossing for some positive integer k when there exist distinct integers i and j so that $a_i \geq k + b_i$ and $b_j \geq k + a_j$. Whenever A and B are incomparable, they are 1-crossing.

Now we have the following extremal problem: Find the maximum size $F(k, w)$ of an antichain $\mathcal{F}$ in $\mathbb{Z}^w$ so that no elements of $\mathcal{F}$ are k-crossing. This problem was posed to us by Piotr Micek and he explained the bounds: $k^{w-1} \leq F(k, w) \leq k^w$. For $w = 1$ and $w = 2$, the lower bound is easily seen to be the correct answer, and it is conjectured that the lower bound is always correct. Bartosz Walczak has produced a very clever proof of this conjecture for the case $k = 3$.

In this talk, we discuss several constructions which explain why the lower bound is best possible and suggest lines of attack for the general case of the conjecture.

This is joint work with Bartosz Walczyk and seven other colleagues. (Received January 14, 2011)

1068-05-116 **Andrew Berget*** (berget@math.ucdavis.edu), Department of Mathematics, University of California, Davis, CA 95616, and **Jia Huang**, School of Mathematics, University of Minnesota, Minneapolis, MN 55455. *Torus sieving of finite Grassmannians.*

The definition of the cyclic sieving phenomenon was recently extended to include the action of an arbitrary finite abelian group. Natural examples of this are found in the action of various tori on finite Grassmannians. I will discuss ongoing work with Jia Huang on this "torus sieving phenomenon," giving explicit formulae for the polynomials involved. (Received January 16, 2011)

1068-05-128 **Rao Li*** (raol@usca.edu), 471 University Parkway, Dept. of mathematical sciences, Aiken, SC 29801. *Some Lower Bounds on the Independence Number of a Graph.* Preliminary report.

The independence number of a graph is the size of a largest independent set of in the graph. Using the inequalities established by Chung (JGT 12 (1988)229-235) and Sivasubramanian (Dis. Math. 309(2009) 3458-3462), we obtained some lower bounds, which involve the largest Laplacian eigenvalue, the number of spanning trees, or the maximum degree, on the independence number of a graph. The lower bounds for the independence number of a graph will be presented in this talk. (Received January 16, 2011)

1068-05-135 **Younjin Kim*** (ykim36@illinois.edu), Mathematics Dept., University of Illinois, Urbana, IL 61801, and **Zoltan Furedi** (z-furedi@math.uiuc.edu), Mathematics Dept., University of Illinois, Urbana, IL 61801. *Cycle-saturated graphs with minimum number of edges.*

A graph G is called F-saturated if it does not contain any copy of F, but for any edge e in the complement of G the graph $G + e$ contains some F. The minimum size of an n-vertex F-saturated graph is denoted by $sat(n, F)$. We give almost exact asymptotics for $sat(n, C_k)$ as k is fixed and $n \to \infty$ where C_k is a cycle with length k. This is a joint work with Zoltán Füredi. (Received January 17, 2011)

1068-05-142 **Jerrold R. Griggs*** (griggs@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29212, **Wei-Tian Li**, Department of Mathematics, University of South Carolina, and **Linyuan Lu**, Department of Mathematics, University of South Carolina. *Harp-free Families of Subsets.*

Given a finite poset P, we consider the largest size $\mathrm{La}(n, P)$ of a family of subsets of $[n] := \{1, \ldots, n\}$ that contains no subposet P. A theorem of Erdős (1945) gives that $\mathrm{La}(n, \mathcal{P}_k) = \Sigma(n, k-1)$, where $\mathcal{P}_k$ is the chain (path) of k elements, and we use $\Sigma(n, m)$ to denote the sum of the m middle binomial coefficients in n. Here we consider forbidding the more general class of *harp posets* $\mathcal{H}(l_1, \ldots, l_k)$ which consists of paths $\mathcal{P}_{l_1}, \ldots, \mathcal{P}_{l_k}$ with their top elements identified and their bottom elements identified. We bound the average number of times a random full chain meets a harp-free family, and discover that if $l_1 > \cdots > l_k \geq 3$, then $\mathrm{La}(n, \mathcal{H}(l_1, \ldots, l_k)) = \Sigma(n, l_1 - 1)$.

However, when equal length "strings" are allowed, the problem remains exceedingly difficult, such as for the diamond posets $\mathcal{H}(3,\ldots,3)$. (Received January 17, 2011)

1068-05-157 **Michal Karonski*** (michal@mathcs.emory.edu), Department of Mathematics and Computer Sci, Emory University, Atlanta, GA 30322. *Vertex-coloring edge-weightings.*

A weighting of the edges of a graph with integer weights gives rise to a weighting of the vertices, the weight of a vertex being the sum of the weights of its incident edges.It is natural to consider edge weighting where we require that *adjacent* vertices have different weights — that is, the vertex weighting induce a proper coloring of the graph.

Karoński, Łuczak and Thomason in 2001 conjectured that the edges of every graph that does not contain a component isomorphic to K_2 can be weighted with the integers $\{1,2,3\}$ such that the resultant vertex weighting is a proper coloring.

In my talk I will discuss some recent developments regarding the above conjecture and a related problem of edge-weighting in which we require that *all* vertices have different weights, i.e., weighting which induces a trivial vertex coloring. (Received January 17, 2011)

1068-05-167 **Jonathan D Browder*** (browder@math.washington.edu), 1620 N 45th St Apt 203, Seattle, WA 98103. *Face Numbers of Cohen-Macaulay Flag Complexes.*

A simplicial complex Δ is *flag* if whenever τ is a subset of the vertices of Δ such that any two elements of τ form an edge in Δ then τ is itself a face of Δ. In other words, flag complexes are simplicial complexes that are completely determined by their edges. It was conjectured by Kalai and proved by Frohmader that if Δ is a d-dimensional flag complex, then there is another d-dimensional simplicial complex, Γ, which has the same number of faces as Δ in each dimension and is *balanced* (that is, properly d-colorable). Kalai further conjectured that if Δ is in addition Cohen-Macaulay, we may take Γ to be Cohen-Macaulay as well.

In this talk I will exhibit a large class of complexes for which Kalai's conjecture holds, and explain the methods of the proof, which involves finding an appriate isomorphic image of the Stanley-Reisner ring. I will also note how our class contains the class of Cohen-Macaulay complexes arising as independence complexes of graphs of sufficient girth. (Received January 17, 2011)

1068-05-171 **Gabor Hetyei*** (ghetyei@uncc.edu), Department of Mathematics and Statistics, UNC-Charlotte, 9201 University City Blvd., Charlotte, NC 28223. *André permutations and similar permutation classes avoiding a single barred (generalized) pattern.*

We show that André permutations, as well as simsun permutations, may be equivalently defined as permutations avoiding a single barred (generalized) pattern on four letters. As a generalization of these findings, we describe all permutation classes avoiding a single barred generalized pattern of the form $a-\overline{b}-cd$ or the reverse or the complement thereof. Besides variants of André permutations, most of these permutation classes turn out to be equivalently definable as permutations avoiding a generalized pattern of the form $a-bc$, these were completely described by Claesson. Only three essentially different classes remain, one was described in a recent work of Burnstein and Lankham, one has a straightforward description, the third exhibits an astonishing degree of complexity. We focus on this third class which we call Foata permutations. It has a generating function in a noncommutative algebra representable as the algebra generated by the formal integration operator and by the operator arising by multiplying each function of t by the variable t. Counting them by descent sets leads to the problem of enumerating all ways to play a certain patience game. This is a report on work in progress. (Received January 17, 2011)

1068-05-172 **Gyula O.H. Katona*** (ohkatona@renyi.hu), Budapest, Hungary. *Finding at least one excellent element in two rounds.*

Some elements of the set $[n]=\{1,2,\ldots,n\}$ are *excellent*. Their number and positions are unknown. Subsets of $[n]$ can be used for tests. If this test is $A\subset[n]$ then the result of the test is YES if at least one of the excellent elements is in A. Otherwise the answer is NO. The goal of the search is to find at least one of the excellent ones, or to claim that there is none. If the choice of the test can depend on the results of the previous ones (*adaptive search*) then the minimum number of tests is trivially $\lceil\log_2 n\rceil$. The situation is very different when the tests are chosen in advance (*non-adaptive search*). We prove that the number of tests is at least n in a non-adaptive search, that is there is no better method than testing all one-element sets. This is surprising, since in the case when the number of excellent elements is known to be 1 then best non-adaptive search has only $\lceil\log_2 n\rceil$ tests. The case of two rounds is also investigated. Then a family of subsets is used for tests in the first round and, depending on the sequence of answers, another family of subsets forms the second round. We prove that the number of tests in the worst case is at least $(2+o(1))\sqrt{n}$, and this is sharp. (Received January 18, 2011)

1068-05-186 **Tricia Muldoon Brown*** (patricia.brown@armstrong.edu), Department of Mathematics, Armstrong Atlantic State University, 11935 Abercorn St, Savannah, GA 31419. *An excedance statistic for signed permutations.* Preliminary report.

We define an excedance statistic for the group of signed permutations and use this statistic to describe the h-vector of the barycentric subdivision of the d-dimensional cube in a result analogous to Stanley's result for the barycentric subdivision of the simplex. This provides a relationship between the new excedance statistic and the Type B Eulerian numbers. Further we discuss applications of the signed excedance statistic to the local h-vector of this subdivision. (Received January 18, 2011)

1068-05-208 **Harout Aydinian**, **Eva Czabarka*** (czabarka@math.sc.edu) and **Laszlo A Szekely**. *Higher dimensional transversals in M dimensional grids.* Preliminary report.

In an earlier paper with K. Engel and P.L. Erdős we investigated a packing problem in M-dimensional grids, where bounds are given for the number of allowed entries in axis-parallel directions (i.e. in subgrid $M-1$ coordinates are fixed). This concept is motivated by error correcting codes and more-part Sperner theory, and it is closely connected to orthogonal arrays. Here we extend this concept from 1 to d-dimension: the bounds are given on the number of allowed entries in a subgrid with $M-d$ coordinates fixed. We prove that there are packing arrays that always reach the natural upper bound for their size, and prove some related extremal results. (Received January 18, 2011)

1068-05-220 **Nan Li*** (nan@math.mit.edu), MA. *h-polynomial of half open hypersimplices.*

The (k,n)-th hypersimplex $\Delta_{k,n}$ is defined as the slice of the hypercube $[0,1]^{n-1}$ located between the two hyperplanes $\sum x_i = k-1$ and $\sum x_i = k$. It is well-known that the normalized volume of $\Delta_{k,n}$ is the Eulerian number $A_{k,n-1}$, i.e., the number of permutations in $n-1$ letters and $k-1$ exceedances. In this paper, we study the h-polynomial of the half open hypersimplex $\Delta'_{k,n}$, defined as $\Delta_{k,n}$ if $k=1$, and $\Delta_{k,n}$ with the face $\sum x_i = k-1$ removed if $k>1$. It is clear that the sum of all the coefficients in the h-polynomial of $\Delta'_{k,n}$ is $A_{k,n-1}$. The main result of this paper says that the coefficient of x^s in the h-polynomial is the number of permutations in $n-1$ letters, $k-1$ exceedances and s descents. (Received January 18, 2011)

1068-05-227 **Jerrold R. Griggs**, **Wei-Tian Li*** (li37@mailbox.sc.edu) and **Linyuan Lu**. *The Largest Poset-Free Families and the Maximum Lubell Function Value.*

The Lubell function $\bar{h}(\mathcal{F})$ of a family $\mathcal{F}$ of subsets of $[n]=\{1,\dots,n\}$ is defined to be the average number of times that a random full chain meets $\mathcal{F}$. This value provides an upper bound on the size of the family $\mathcal{F}$. Given a finite poset P, a family is P-free if it does not contain P as a subposet. By evaluating the value of $\max \bar{h}(\mathcal{F})$ of P-free families, Griggs, Li, and Lu obtain the exact sizes of largest P-free families for several diamond-shaped posets P. For these diamond-shaped posets P_is, we define the strong ordinal sum $P = P_1 \oplus_s \cdots \oplus_s P_k$: for $x,y \in P$, $x \le y$ if either (1) $x,y \in P_i$ for some i and $x \le y$ in P_i or (2) $x \in P_i$ and $y \in P_j$ for $i \le j$. In addition, the maximum element of P_i is identified to the minimal element of P_{i+1}. In the talk, we will determine the size of the largest families that do not contain the new poset $P_1 \oplus_s \cdots \oplus_s P_k$ using the Lubell function method. (Received January 20, 2011)

1068-05-236 **Rod Downey**, **Noam Greenberg**, **Carl G Jockusch** and **Kevin G Milans*** (milans@math.sc.edu). *Binary subtrees with few path labels.*

A rooted tree is *k-ary* if all non-leaves have k children; it is *complete* if all leaves have the same distance from the root. Let T be the complete ternary tree of depth n. If each edge in T is labeled 0 or 1, then the labels along the edges of a path from the root to a leaf form a *path label* in $\{0,1\}^n$. Let $f(n)$ be the maximum, over all $\{0,1\}$-edge-labeled complete ternary trees T of depth n, of the minimum number of distinct path labels on a complete binary subtree of depth n in T.

The problem of bounding $f(n)$ arose in studying a problem in computability theory, where it was hoped that $f(n)/2^n$ tends to 0 as n grows. This is true; we show that $f(n)/2^n$ is $O\left(2^{-c\sqrt{n}}\right)$ for a positive constant c. From below, we show that $f(n) \ge (1.548)^n$ for sufficiently large n. (Received January 19, 2011)

1068-05-240 **Linyuan Lu*** (lu@math.sc.edu), Columbia, SC 29208, and **Xing Peng**. *A Fractional Analogue of Brooks' Theorem.*

Let Δ be the maximum degree of a connected graph G. Brooks' theorem states that the only connected graphs with chromatic number $\Delta+1$ are complete graphs and odd cycles. Here we proved a fractional version of Brooks' theorem: we classified all connected graphs G with the fractional chromatic number $\chi_f(G) \ge \Delta$. (Received January 19, 2011)

1068-05-247 **Guantao Chen*** (gchen@gsu.edu), **Songling Shan** and **Han Ren**. *Homomorphically Irreducible Trees in Locally Connected Graphs.* Preliminary report.

Given a graph, a spanning tree without vertices of degree 2 is called a homomorphically irreducible spanning tree (HIST) of the graph. A. Hill conjectured that every triangulation of the plane other than K_3 contains a HIST. J. Malkevitch extended this conjecture to a near-triangulation of the plane(a 2-connected plane graph with all but at most one faces are triangles). Albertson, Berman, Hutchinson, and Thomassen confirmed the conjecture. In the same paper, they asked whether *every triangulation of a surface contain a HIST*. We show that every connected and locally connected graph with more than 3 vertices contains a HIST. Consequently, every triangulation of a surface contains a HIST. Additionally, we show that, for every vertex v in a connected and locally connected graph with at least two vertices, there is a contractible edge incident to v. (Received January 19, 2011)

1068-05-249 **Steven Klee*** (klee@math.ucdavis.edu), Department of Mathematics, 1 Shields Ave, University of California, Davis, CA 95616, and **Isabella Novik**. *Centrally symmetric manifolds with few vertices.* Preliminary report.

A simplicial complex Δ is *centrally symmetric* if it admits a free involution. For each positive integer d and each integer $0 \leq i \leq d-1$, we construct a simplicial manifold, $\mathcal{B}(i,d)$, that can be realized as a full-dimensional subcomplex of the boundary complex of a d-dimensional cross-polytope. The complex $\mathcal{B}(i,d)$ satisfies $\widetilde{H}_i(\mathcal{B}(i,d);\mathbb{Z}) = \mathbb{Z}$ and $\widetilde{H}_j(\mathcal{B}(i,d);\mathbb{Z}) = 0$ for $j \neq i$. Moreover, the boundary complex of $\mathcal{B}(i,d)$ is a centrally-symmetric triangulation of $\mathbb{S}^i \times \mathbb{S}^{d-i-2}$ with only $2d$ vertices. Existence of such a triangulation for the case of $i = d-i-2$ was conjectured by Sparla. (Received January 19, 2011)

1068-05-250 **Sarah K Mason*** (masonsk@wfu.edu) and **Jeff Remmel**. *Partitions and compositions: A tale of two symmetries.*

This talk explores the role of partitions in symmetric function theory and their counterpart, compositions, in quasisymmetric function theory. We look at properties that are common to both settings, ways that they differ, and interactions between the two. Along the way we develop several new bases and explain how these can be used to prove results in both settings. (Received January 19, 2011)

1068-05-267 **Joshua N Cooper*** (cooper@math.sc.edu), 1523 Greene St., Department of Mathematics, LeConte College, USC, Columbia, SC 29208, and **Aaron Dutle** (dutle@math.sc.edu), 1523 Greene St., Department of Mathematics, Columbia, SC 29208. *Spectra of Hypergraphs.*

We present a systematic spectral theory of hypergraphs that closely parallels graph spectral theory. Classic work by Gel'fand-Kapranov-Zelevinsky and Canny, as well as more recent developments by Chang, Lim, Pearson, Qi, Zhang, and others has led to a rich understanding of "hyperdeterminants" of hypermatrices, a.k.a. multidimensional arrays. Hyperdeterminants share many properties with determinants, but the context of multilinear algebra is substantially more complicated than the linear algebra required to understand spectral graph theory (i.e., ordinary matrices). Nonetheless, it is possible to define eigenvalues of a tensor via its characteristic polynomial and variationally. We apply this notion to the "adjacency hypermatrix" of a uniform hypergraph, and prove a number of natural analogues of graph theoretic results. Computations are particularly cumbersome with hyperdeterminants, so we discuss software developed in Sage which can perform basic calculations on small hypergraphs. Open problems abound, and we present a few directions for further research.

Joint work with Aaron Dutle of the University of South Carolina. (Received January 19, 2011)

1068-05-270 **Federico Ardila**, **Megan Owen*** (maowen@berkeley.edu) and **Seth Sullivant**. *Geodesics in CAT(0) Cubical Complexes.*

A cubical complex is a polyhedral complex in which all the cells are unit cubes. By giving each cube the Euclidean L2 metric, we get a natural metric on the whole complex. These complexes arise in such areas as geometric group theory, reconfigurable systems, and phylogenetics. If a cubical complex is globally non-positively curved or CAT(0), then there is a unique shortest path or geodesic between any two points in the complex. We present an algorithm for finding this path, which makse use of a bijection between CAT(0) cubical complexes and posets with inconsistent pairs. (Received January 19, 2011)

1068-05-283 **Michelle L Wachs*** (wachs@math.miami.edu). *Unimodality of q-Eulerian numbers and (p,q)-Eulerian numbers.*

The Eulerian numbers enumerate permutations in the symmetric group S_n by their number of excedances or by their number of descents. It is well known that they form a symmetric and unimodal sequence of integers. In this talk, which is based on joint work with John Shareshian and Anthony Henderson, we consider the q-analog of the Eulerian numbers obtained by considering the joint distribution of the major index and the

excedance number, and the (p,q)-analog of the Eulerian numbers obtained by considering the joint distribution of the major index, descent number and excedance number. We show that the q-Eulerian numbers form a symmetric and unimodal sequence of polynomials in q and the (p,q)-Eulerian numbers refined by cycle type form a symmetric and unimodal sequence of polynomials in p and q. The proofs of these results rely on the Eulerian quasisymmetric functions introduced by Shareshian and Wachs, and on symmetric and quasisymmetric function theory. (Received January 19, 2011)

1068-05-291 **Christine E Heitsch*** (heitsch@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332. *Meanders and RNA Folding.*

A closed meander of order n is a non-self-intersecting closed curve in the plane which crosses a horizontal line at $2n$ points. Meanders occur in a variety of settings from combinatorial models of polymer folding to the Temperley-Lieb algebra, yet the exact meander enumeration problem remains open. Building on results for plane trees and noncrossing partitions motivated by the biology of RNA folding, we prove that meanders are connected under appropriately defined local move transformations. The resulting meander graphs have some interesting characteristics and suggest new approaches to the enumeration question. As we will explain, meanders also relate to the challenging biomathematical problem of comparing different possible folds for an RNA sequence. (Received January 19, 2011)

1068-05-327 **Peter J Slater*** (slaterp@math.uah.edu), Mathematical Sciences Department, University of Alabama in Huntsville, Huntsville, AL 35899. *Neighborhood sums under graph labelings.*

Problems involving assigning weights w1,w2,...wn to the vertices of a graph include minimax, maximin, and minispread problems for open/closed neighborhoods. Such problems will be discussed in detail. An investigation of these problems leads to a consideration of many graph theory problems (such as domination, independence, and hamiltonian cycle) as labeling problems. This viewpoint will be briefly explored. (Received January 20, 2011)

1068-05-331 **Jie Ma**, School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332, and **Xingxing Yu***, School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332. *K_5-subdivisions in 5-connected nonplanar graphs.*

Kuratowski's theorem states that a graph is planar iff it contains no subdivision of K_5 or $K_{3,3}$. Seymour and independently Kelmans conjectured in the 1970s that every 5-connected nonplanar graph contains a subdivision of K_5. We show that this is ture when the graph contains K_4^- as a subgraph. We also show that why excluding K_4^- is useful. Joint work with Jie Ma. (Received January 20, 2011)

06 ► Order, lattices, ordered algebraic structures

1068-06-223 **Shahriar Shahriari*** (sshahriari@pomona.edu), Depatment of Mathematics, Pomona College, 610 N. College Ave, Claremont, CA 91711. *Nested Chain Decompositions in Normalized Matching Posets.* Preliminary report.

In 1975, Jerry Griggs conjectured that a normalized matching poset (aka an LYM poset) has a nested chain decomposition. This elegant conjecture remains open. In this talk, we will survey what is known and present a method for finding nested chain decompositions for most (but not all) rank three normalized matching posets. (Received January 18, 2011)

11 ► Number theory

1068-11-290 **Neil Lyall*** (lyall@math.uga.edu). *Some results in arithmetic combinatorics.*

We shall report on recent work with collaborators. (Received January 19, 2011)

1068-11-301 **Yasuyuki Kachi*** (kachi@math.ku.edu), Department of Mathematics, 1460 Jayhawk Boulevard, Lawrence, KS 66045, and **Joel Font** (jfont@math.ku.edu), Department of Mathematics, 1460 Jayhawk Boulevard, Lawrence, KS 66045. *Stirling's formula, functional identities, and special values of Riemann's zeta function.* Preliminary report.

Stirling's formula offers ball-park estimates of $m!$. This three-century-old formula may be seen today as something that attracts amateur math enthusiasts, but it has actually got some interesting mathematics in it that has to do with the zeta function $\zeta(s)$. Numerous results that sharpen the Stirling's original estimates are known. The 'Euler-Maclaurin version' offers an intriguing link between $m!$ and the Bernoulli numbers, while it has one crucial drawback. Today I report on a different formula that has satisfactory features. It consists of under- and

over-estimates of log $m!$. The upshot of it is we can write both error terms as series of $(m+1)^{-1}...(m+r)^{-1}$. The under-estimate part is found in 'Wikipedia' (no mention of who discovered it), so our contribution is the over-estimate part. By truncating the series at an r-th term, we get refined (r-th degree) estimates of $m!$. I share with you 1. a new integral formula that expresses the Euler's constant 0.5772156.., 2. a new functional identity of $\zeta(s)$, and 3. a new Wallis type product expression of the number $\zeta(3) = 1^{-3}+2^{-3}+3^{-3}+4^{-3}+\cdots$, all came out while studying the subject. (Received January 20, 2011)

13 ► Commutative rings and algebras

1068-13-32 **B. Kubik** (bethany.kubik@ndsu.edu), NDSU Dept # 2750, PO Box 6060, Fargo, ND 58108-6050, **M. Leamer*** (s-mleamer1@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, PO Box 880130, Lincoln, NE 68588-0130, and **S. Sather-Wagstaff** (sean.sather-wagstaff@ndsu.edu), NDSU Dept # 2750, PO Box 6050, Fargo, ND 58108-6050. *Homology of artinian and Matlis reflexive modules.*

Let R be a commutative noetherian ring, and let M and N be R-modules. We investigate the properties of the functors $\operatorname{Tor}_i^R(M,-)$ and $\operatorname{Ext}^i_R(M,-)$. For instance, we show the following:

(1) if M is artinian and N is noetherian, then $\operatorname{Hom}_R(M,N)$ has finite length;

(2) if M and N are artinian, then $M \otimes_R N$ has finite length;

(3) if M and N are artinian, then $\operatorname{Tor}_i^R(L,L')$ is artinian and $\operatorname{Ext}^i_R(L,L')$ is noetherian over a semilocal ring; and

(4) if M is artinian and N is Matlis reflexive, then $\operatorname{Ext}^i_R(M,N)$, $\operatorname{Ext}^i_R(M,N)$, and $\operatorname{Tor}_i^R(M,N)$ are Matlis reflexive.

Also, we study the vanishing behavior of these functors. (Received December 21, 2010)

1068-13-97 **Andrew R. Kustin*** (kustin@math.sc.edu). *The Generic Hilbert-Burch matrix.*

Let X be the set of 3×2 matrices whose entries are homogeneous forms of degree c in the polynomial ring $k[x,y]$ and let Y be the set of 3×1 matrices whose entries are homogeneous forms of degree $2c$. Notice that X may be identified with an ordinary affine space of dimension $6c+6$ and Y may be identified with an ordinary affine space of dimension $6c+3$. The function $\Phi : X \to Y$, which is given by taking the three 2×2 minors, induces a polynomial function from $6c+6$ space to $6c+3$ space. We ask "Does there exist a **polynomial** section of Φ?" That is, does there exist a dense open subset U of the image of Φ, an open cover $\{U_i\}$ of U, and **polynomial** functions $\sigma_i : U_i \to X$, so that $\Phi \circ \sigma_i$ is the identity function on U_i, for each i? (Received January 14, 2011)

1068-13-196 **Janet Striuli*** (jstriuli@fairfield.edu), Fairfield, CT, and **Hamidreza Rahmati** and **Claudia Miller**. *A property of the Koszul homology module over Gorenstein rings.* Preliminary report.

Let R be a local Gorenstein ring of dimension d. Let I be an ideal minimally generated by l elements and of grade g. By a result of Golod, if all the non-vanishing Koszul homology $H_j(I), j = 0,\dots,l-g$ are Cohen-Macaulay, then $Ext^g(H_i(I),R) \cong H_{l-g-i}(I)$.

In this talk we will present a duality that holds for a general ideal I of R, of which Golod's result is a corollary. This is joint work with Hamidreza Rahmati and Claudia Miller. (Received January 18, 2011)

1068-13-216 **Louiza Fouli*** (lfouli@math.nmsu.edu), Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88003, and **Susan Morey** (morey@txstate.edu), Department of Mathematics, Texas State University, San Marcos, TX 78666. *Minimal Reductions of edge ideals of graphs.* Preliminary report.

Let R be a Noetherian ring and let I be an ideal. Recall that J is a reduction of I if $J \subset I$ and $I^{n+1} = JI^n$ for some nonnegative integer n. Northcott and Rees proved that if R is a Noetherian local ring with infinite residue field then there are infinitely many reductions of I. We focus on the class of square–free monomial ideals that are generated in degree 2. These correspond to edge ideals of graphs. We investigate various properties of reductions of such ideals and prove a formula for the core of a special subclass. (Received January 18, 2011)

1068-13-252 **Neil Epstein** and **Yongwei Yao***, 750 COE, 7th floor, 30 Pryor Street, Department of Mathematics and Statistics, Georgia State University, Atlanta, GA 30303. *Criteria for flatness and injectivity.*

Let R be a commutative Noetherian ring. We give criteria for flatness of R-modules in terms of associated primes and torsion-freeness of certain tensor products. This allows us to develop a criterion for regularity if R

has characteristic p, or more generally if it has a locally contracting endomorphism. Dualizing, we give criteria for injectivity of R-modules in terms of coassociated primes and (h-)divisibility of certain Hom-modules. This is joint work with Neil Epstein. (Received January 19, 2011)

1068-13-271 **Jinjia Li***, Department of Mathematics, University of Louisville, Louisville, KY 40208. *Socles of Frobenius powers.*

Let (R, m) be a graded local ring in characteristic $p > 0$ with maximal ideal m. In general, it is difficult to predict how the lengths and degrees of the socle of $R/m^{[q]}$ behave asymptotically when $q = p^e$ grows. We investigate some special cases where the behaviors of the socle of $R/m^{[q]}$ are better understood. (Received January 19, 2011)

1068-13-279 **Florian Enescu*** (fenescu@gsu.edu), 30 Pryor St 750 COE, Georgia State University, Department of Mathematics and Statistics, Atlanta, GA 30303. *A finiteness condition on local cohomology.* Preliminary report.

The talk will discuss a condition on a local Cohen-Macaulay F-injective ring of positive characteristic $p > 2$ which implies that its top local cohomology module with support in the maximal ideal has finitely many Frobenius compatible submodules. A conjecture will be formulated along these lines. (Received January 19, 2011)

1068-13-302 **Livia Hummel*** (hummell@uindy.edu), 1400 East Hanna Ave, Indianapolis, IN 46227. *The homological dimensions of coherent Gorenstein rings.* Preliminary report.

Totally reflexive modules and Gorenstein homological dimensions have played an important role in the development of the theory of non-Noetherian Gorenstein rings. Coherent Gorenstein rings are also linked to the coherent rings of finite FP-injective dimension studied by Ding and Chen. This talk will discuss connections between recent work in homological dimensions and characterizations of Gorenstein rings, as well as influences laying the groundwork for a notion of coherent complete intersection rings. (Received January 19, 2011)

1068-13-319 **Brett Barwick*** (barwicjb@mailbox.sc.edu). *An Algorithmic Approach to the Quillen-Suslin Theorem over $\mathbb{Z}[x_1, \ldots, x_n]$.* Preliminary report.

In 1976 D. Quillen and A. Suslin independently proved what is now called the Quillen-Suslin Theorem, resolving a famous question posed by J.P. Serre in 1955. The Quillen-Suslin Theorem asserts that every finitely generated projective module P over $k[x_1, \ldots, x_n]$, with k a field, is free. One can extend this result to any polynomial ring where the coefficient ring is a principal ideal domain, and so in particular it holds over $\mathbb{Z}[x_1, \ldots, x_n]$. However, given a presentation of a finitely generated projective $\mathbb{Z}[x_1, \ldots, x_n]$-module by generators and relations it is a nontrivial task to compute a free generating set. The problem of computing such a free generating set is equivalent to the problem of extending an $m \times n$ $(m \leq n)$ unimodular matrix over $\mathbb{Z}[x_1, \ldots, x_n]$ to an $n \times n$ invertible matrix over $\mathbb{Z}[x_1, \ldots, x_n]$. This talk aims to give a brief overview of an algorithm presented by Logar-Sturmfels in 1992 which produces such an invertible matrix when the coefficient ring is a field, as well as some issues that arise in generalizing this algorithm to work over the integers. (Received January 20, 2011)

1068-13-324 **Liana M Sega*** (segal@umkc.edu). *Vanishing of (co)homology over absolutely Koszul rings.*

An absolutely Koszul ring is a local ring with the property that every finitely generated module has a syzygy that is Koszul, in the sense that its associated graded module has a linear resolution. This property allows to shift vanishing of (co)homology to the associated graded objects. Recent work of the author in collaboration with I. Henriques shows that generic Gorenstein algebras with maximal ideal $\mathfrak{m}$ satisfying $\mathfrak{m}^4 = 0$ are absolutely Koszul. I will show that such rings satisfy the Auslander-Reiten conjecture. (Received January 20, 2011)

1068-13-326 **Joseph P. Brennan***, Department of Mathematics, University of Central Florida, 4000 Central Florida Blvd., Orlando, FL 32816, and **Heath Martin**, Department of Mathematics, University of Central Florida, 4000 Central Florida Blvd., Orlando, FL 32816. *Sequentially Cohen-Macaulayness of ideals associated to uniform clutters.* Preliminary report.

Associated to a clutter is a monomial ideal. This talk will investigate the question of when these ideals are Sequentially Cohen-Macaulay. (Received January 20, 2011)

1068-13-334 **Frank Moore** and **Hamid Rahmati*** (hrahmati@syr.edu). *Standard systems of parameters and rings with final local cohomology.* Preliminary report.

Let $(R, \mathfrak{m})$ be a local commutative noetherian ring. It is known that the local cohomology modules $\mathrm{H}^i_{\mathfrak{m}}(R)$, for $i < \dim R$, are finitely generated if and only if there exists an integer n such that every system of parameters

$\underline{x} = x_1, \ldots, x_d$ in $\mathfrak{m}^n$ is standard, that is to say $\underline{x}$ satisfies

$$(\underline{x})\, \mathrm{H}^i_{\mathfrak{m}}(R/(x_1, \ldots, x_j)) = 0$$

for all non-negative integers i, j with $i + j < d$. We give an upper bound for the smallest n with this property. (Received January 20, 2011)

14 ► Algebraic geometry

1068-14-27 **Jiayuan Lin*** (linj@canton.edu), Department of Mathematics, SUNY Canton, 34 Cornell Drive, Canton, NY 13617, and **Janice Wethington** (janice1729@yahoo.com), 1509 Stevens Creek Drive, North Augusta, SC 29860. *On the Thom-Boardman Symbols for Polynomial Multiplication Maps.*

The Thom-Boardman symbol was first introduced by Thom and later generalized by Boardman to classify singularities of differentiable maps. Although the Thom-Boardman symbol is realized by a sequence of non-increasing, nonnegative integers, to compute those numbers is extremely difficult. There are only sporadic known results in literature. In the case of polynomial multiplication maps, Robert Varley conjectured that computing the Thom-Boardman symbol for polynomial multiplication reduces to computing the successive quotients and remainders for the Euclidean algorithm applied to the degrees of the two polynomials. In this talk, I will explain our proof of Varley's conjecture. This is a joint work with Janice Wethington. (Received December 17, 2010)

1068-14-58 **Jun Li** and **Christian Liedtke*** (liedtke@math.stanford.edu), Department of Mathematics, 450 Serra Mall, Stanford, CA 94305. *Rational Curves on K3 Surfaces.*

We show that projective K3 surfaces with odd Picard rank contain infinitely many rational curves. Our proof extends the Bogomolov-Hassett-Tschinkel approach, i.e., uses moduli spaces of stable maps and reduction to positive characteristic. (Received January 10, 2011)

1068-14-63 **Adrian Clingher***, Dept. of Mathematics and Computer Science, University of Missouri - St. Louis, One University Blvd., St. Louis, MO 63121, and **Charles F. Doran**, Department of Mathematical Sciences, University of Alberta, Edmonton, Alberta , Canada. *K3 Surfaces of High Picard Rank: A Classification in Terms of Siegel Modular Forms.*

I will discuss a special family of complex algebraic K3 surfaces polarized by the rank seventeen lattice H+E8+E7. In terms of Hodge theory, these surfaces are naturally related to principally polarized abelian surfaces. I will outline the geometry of the correspondence as well as present an explicit classification of these special K3 surfaces in terms of Siegel modular forms. Finally, if time permits, I will discuss some recent work extending these results to lattice polarizations of type H+E7+E7. (Received January 11, 2011)

1068-14-74 **Angela C Gibney*** (agibney@uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602, and **Valery Alexeev**, **David Swinarski**, **Maxim Arap** and **Jim Stankewicz**. *Conformal Blocks Divisors on $\overline{M}_{0,n}$ from $\mathfrak{sl}_2$ and $\mathfrak{sl}_n$.*

Given a simple Lie algebra $\mathfrak{g}$, a positive integer ℓ called the level, and an appropriately chosen n-tuple of dominant integral weights $\overline{\lambda}$ of level ℓ, one can define a vector bundle on the stacks $\overline{M}_{g,n}$ whose fibers are the so-called vector spaces of conformal blocks. On $\overline{M}_{0,n}$, first Chern classes of these vector bundles turn out to be semi-ample divisors, and so define morphisms. In this talk I will discuss what we have learned by looking at the simplest examples of these divisors. (Received January 12, 2011)

1068-14-80 **Sandra Di Rocco**, **Christian Haase** and **Benjamin Nill***, University of Georgia, Math Department, Boyd Building, Athens, GA 30602, and **Andreas Paffenholz**. *Adjunction-theoretic invariants of polarized toric varieties.*

There are interesting open questions in classical adjunction theory which we hope to shed some light on by considering the adjunction theory of toric varieties from a polyhedral viewpoint. Essentially, 'polyhedral adjunction theory' is the question how a rational polytope changes, when we move the facets by a constant value inwards. In this talk we present the convex-geometric invariants corresponding to the unnormalized spectral value and the nef-value of a polarized toric variety associated to a lattice polytope. Our main result shows that an n-dimensional lattice polytope P has lattice width one, if the unnormalized spectral value is at least (n+2)/2. We explain the relation to a paper by Alicia Dickenstein, Sandra Di Rocco and Ragnie Piene and a recent joint result with Alicia Dickenstein on dual defect manifolds.

This is joint work with Sandra Di Rocco, Christian Haase, and Andreas Paffenholz. (Received January 13, 2011)

1068-14-94 **Emre Coskun**, **Rajesh S. Kulkarni** and **Yusuf Mustopa*** (ymustopa@umich.edu). *Ulrich Bundles on del Pezzo Surfaces.*

Ulrich bundles occur naturally in a variety of algebraic and algebro-geometric topics, including determinantal and Pfaffian descriptions of hypersurfaces, the computation of resultants, and the representation theory of generalized Clifford algebras. In this talk I will discuss the connection between the existence of rank r Ulrich bundles on a degree-d del Pezzo surface X and the geometry of curves of degree dr on X. (Received January 14, 2011)

1068-14-121 **David J. Swinarski*** (davids@math.uga.edu) and **Ian Morrison**. *The action of the symmetric group on the moduli space of stable pointed genus zero curves.* Preliminary report.

The symmetric group S_n acts on the moduli space of stable pointed genus zero curves $\overline{M}_{0,n}$ and hence also on its cohomology ring. We describe this action and discuss applications. (Received January 16, 2011)

1068-14-130 **Gordon Heier*** (heier@math.uh.edu), Department of Mathematics, University of Houston, 4800 Calhoun Road, Houston, TX 77204. *Essentially large divisors and degeneracy of integral points.*

We will discuss generalizations of Siegel's classical finiteness theorem for integral points on affine curves to higher dimensions. A class of divisors on projective manifolds, called essentially large divisors, will be introduced to make precise the idea that a divisor with sufficiently many ample components should force sets of integral points in the complement of the divisor to be degenerate. For projective manifolds of small codimension, a necessary and sufficient criterion for a divisor to be essentially large will be established. This is joint work with Min Ru. (Received January 16, 2011)

1068-14-144 **Tolga Karayayla*** (tkarayay@math.upenn.edu). *Classification of Automorphism Groups of Rational Elliptic Surfaces.* Preliminary report.

In this work, I give a classification of automorphism groups of relatively minimal rational elliptic surfaces with section according to the configuration of singular fibers on the surface. The main result is a list of groups for each configuration of singular fibers such that each group in that list is the automorphism group of a rational elliptic surface with the specified singular fibers. Possible configurations of singular fibers on rational elliptic surfaces have been worked out by Persson and Miranda, there are 279 of them. The Mordell-Weil groups (the group of sections of the elliptic surface) have been classified by Oguiso and Shioda. The Mordell-Weil group depends on the configuration of singular fibers. In my work I show that the automorphism group of a rational elliptic surface is the semi-direct product of its Mordell-Weil group and the subgroup of automorphisms preserving the zero section. In this talk I will outline the ideas and the techniques I used for determining this subgroup for each configuration of singular fibers (Received January 17, 2011)

1068-14-145 **Jason Lo*** (locc@missouri.edu). *Polynomial Bridgeland Stable Objects on Threefolds and Their Moduli.*

Polynomial Bridgeland stability was introduced by Arend Bayer on normal projective varieties. One such stability on threefolds, called PT-stability, gives a perspective of higher-rank analogues of the stable pairs studied by Pandharipande and Thomas. We will describe PT-stable objects in the derived category, and discuss what we know about their moduli. (Received January 17, 2011)

1068-14-146 **P Banagere** and **Krishna Hanumanthu*** (khanuma@math.ku.edu), Department of Mathematics, University of Kansas, Lawrence, KS 66045. *Syzygies and geometry of projective varieties.*

The syzygyies of a very ample line bundle L on a projective variety $X \subset \mathbb{P}(H^0(X, L))$ carry information about the geometry of the embedding. This interplay was first studied in depth by M. Green and R. Lazarsfeld. This led to the notion of N_p property for L, where p is a natural number. While this situation is fairly well understood for curves, there is no completely satisfactory answer in higher dimensions. This talk will deal with some new results in this direction for surfaces. (Received January 17, 2011)

1068-14-152 **Francisco J Gallego**, **Miguel Gonzalez** and **Bangere P Purnaprajna*** (purna@ku.edu), Department of Mathematics, University of Kansas, Lawrence, KS 66045. *Deformations of canonical morphism and the moduli of surfaces of general type.*

I will talk about the deformation of finite maps and show how to use this deformation theory to construct varieties with given invariants in a projective space. Among other things, we prove a criterion that determines when a finite map can be deformed to a one–to–one map. We use this criterion to construct new simple canonical surfaces–so-called by the Italian geometer Enriques– with different c_1^2 and χ. Our general results enable us to

describe some new components of the moduli of surfaces of general type. We also find infinitely many moduli spaces $\mathcal{M}_{(x',0,y)}$ having one component whose general point corresponds to a canonically embedded surface and another component whose general point corresponds to a surface whose canonical map is a degree 2 morphism, a situation that is quite different from the case for curves or surfaces such as K3. (Received January 17, 2011)

1068-14-164 **Ravindra V. Girivaru***, 354 Express Scripts Building, 1 University Boulevard, University of Missouri, St. Louis, MO 63121. *Splitting criteria for vector bundles.*

We shall survey some recent results on splitting criteria for vector bundles on hypersurfaces. (Received January 17, 2011)

1068-14-245 **Matt Deland*** (deland@math.columbia.edu). *Moduli Spaces of Rational Curves on Hypersurfaces in Projective Space.*

Understanding the structure of moduli spaces of rational curves on varieties is a subtle and often difficult project. Even for the case of a smooth Fano hypersurface in projective space, much remains unknown. To date, studying the spaces of degree e rational curves on a general, smooth, degree d hypersurface in projective n-space involves applying Mori's bend and break argument. Unfortunately, this argument only applies in a certain numerical range of d and n. I will review what is known and then I will discuss a new argument that does not rely on "breaking" rational curves to conclude irreducibility of these moduli spaces in new degree ranges. (Received January 19, 2011)

1068-14-266 **Brian Osserman***, Department of Mathematics, One Shields Ave, University of California, Davis, CA 95616. *Special determinants in higher-rank Brill-Noether theory.*

We will give a brief survey of the role of special determinants in higher-rank Brill-Noether theory, including the original work of Bertram, Feinberg, and Mukai on smooth curves in the case of canonical determinant, generalizations to other determinants, and work (joint with Montserrat Teixidor i Bigas) on degeneration techniques in this context. (Received January 19, 2011)

1068-14-285 **Aaron Abrams*** (abrams@mathcs.emory.edu), 400 Dowman Dr, Suite W401, Atlanta, GA 30322, and **James Pommersheim**. *Area relations in triangulations of a square.* Preliminary report.

Starting with a simplicial complex T that is homeomorphic to a 2-dimensional disk with four boundary points, we consider all ways to realize the complex in the plane such that the edges are straight line segments and the boundary is a square. We show that there is an irreducible polynomial, which depends on the combinatorics of T, that must be satisfied by the areas of the triangles. We present various results about the degree and the coefficients of this polynomial. (Received January 19, 2011)

15 ► Linear and multilinear algebra; matrix theory

1068-15-56 **Laura A Smithies*** (smithies@math.kent.edu), Department of Mathematical Sciences, Kent State University, Kent, OH 44242. *Decompositions of Tridiagonal Nearly Normal Matrices.*

Recall that an n-dimensional complex matrix M is *normal* if its commutant with its adjoint $[M, M^*] = MM^* - M^*M = M\bar{M}^t - \bar{M}^tM$ is the zero matrix. Define a matrix to be *nearly normal* if $[M, M^*]$ has minimal non-zero rank. In this talk, we will explain the special structure that tridiagonal nearly normal matrices satisfy. We will show how when n is odd (respectively, even) this structure allows us to give explicit (respectively, implicit) formulas for the spectral and singular value decompositions of tridiagonal nearly normal matrices. We also indicate possible directions for further research. (Received January 10, 2011)

1068-15-104 **Jiehua Zhu** and **Xiezhang Li*** (xli@georgiasouthern.edu). *A full row-rank system matrix generated by the strip-based projection model in parallel-beam image reconstruction.*

Let $Cu = k$ be an underdetermined linear system generated by the strip-based projection model in parallel-beam image reconstruction, where C is row-rank deficient. In the case of one scanning direction, an index set H is specified such that a full row-rank matrix F, obtained by deleting rows of C with row index in H, contains the maximum linearly independent rows of C. Therefore, the corresponding system $Fu = h$ is equivalent to $Cu = k$ and consequently, the cost of an image reconstruction from $Fu = h$ is reduced. (Received January 14, 2011)

1068-15-255 **Alessandro Arsie*** (alessnadro.arsie@utoledo.edu), University of Toledo, Department of Mathematics, MS 942, 2801 W. Bancroft St., Toledo, OH 43606, and **Christian Ebenbauer** (ce@ist.uni-stuttgart.de), University of Stuttgart, Institute for Systems Th. Automatic Control, Pfaffenwaldring 9, Room 2.244, 70550 Stuttgart, Germany.
Deformations of Lax equations, projections and applications.

If $A(t)$ and $B(t)$ are $n \times n$ matrices with sufficiently smooth entries, it is well-known that equation in Lax pair form

$$\frac{d}{dt}A(t) = [A(t), B(t)] \tag{1}$$

defines isospectral deformations of A. In particular, all the k-moments I_k in the eigenvalues and all the elementary symmetric polynomials in the eigenvalues are also preserved under a Lax flow. It is therefore interesting to ask how to construct special deformations of Lax systems (1) in the form

$$\frac{d}{dt}A(t) = [A(t), B(t)] + Z_j(A(t)), \tag{2}$$

such that the resulting flow decreases or increases the j-th moment I_j, while at the same time preserving the other moments. In this talk we present two methods to construct such deformations and discuss some of their properties. We also discuss how to construct such deformations when one is interested to perturb the evolution of non-trivial conservation laws associated to specific Lax systems that appears to be completely integrable. In particular these methods allow to alter the Frobenius norm of a symmetric matrix, while keeping constant its trace and the other moments. Time permitting, relations to control systems and Poisson geometry will be highlighted. (Received January 19, 2011)

16 ► Associative rings and algebras

1068-16-212 **Lars Winther Christensen*** (lars.w.christensen@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042, and **David A Jorgensen**. *Tate (co)homology via pinched complexes.* Preliminary report.

Let R be a ring. For complexes of R-modules we introduce two constructions, which we call the pinched tensor product complex and the pinched Hom complex. (Visualizations of the complexes will be provided to justify the nomenclature.)

Our motivation for studying these constructions is their connections to Tate (co)homology. (1) For R-modules M and N that allow complete resolutions, one can compute the Tate cohomology groups $\widehat{\operatorname{Ext}}^R_*(M,N)$ as the cohomology of the pinched Hom complex for these resolutions. (2) A parallel result for Tate homology opens to a construction of minimal complete resolutions for certain tensor product modules. (Received January 18, 2011)

1068-16-232 **Yi-Lin Cheng*** (ylincheng@gmail.com), Department of Mathematics, Austin Peay State University, and **Siu-Hung Ng** (rng@iastate.edu), Department of Mathematics, Iowa State University. *On Hopf algebras of dimension 4p.*

We consider the classification of Hopf algebras of dimension pq^2 over an algebraically closed field where p, q are distinct primes. In this talk, we will show a non-semisimple Hopf algebra H of dimension $4p$ with p an odd prime is pointed if H contains more than two group-like elements. We also give the complete classification for non-semisimple Hopf algebras of dimension 20,28 and 44. (Received January 19, 2011)

17 ► Nonassociative rings and algebras

1068-17-183 **Brant Jones*** (brant@math.jmu.edu) and **Anne Schilling**. *Affine structures and a tableau model for E_6 crystals.*

Let $\mathfrak{g}$ be an affine Kac–Moody algebra and $U'_q(\mathfrak{g})$ be the associated quantized affine algebra. Kirillov–Reshetikhin modules are finite dimensional $U'_q(\mathfrak{g})$-modules labeled by a node r of the Dynkin diagram together with a nonnegative integer s. It is expected that each Kirillov–Reshetikhin module has a crystal basis. In this talk, we focus on type $E_6^{(1)}$ for which Chari has given the decomposition of Kirillov–Reshetikhin modules into classical highest-weight modules. We extend the classical crystals for these modules to give an explicit combinatorial realization of the Kirillov–Reshetikhin crystals when r is 1, 6 or 2 in the Bourbaki labeling and s is arbitrary. This realization is based on the technique of promotion that has been used for other types by Shimozono and Fourier, Okado, Schilling.

This is joint work with Anne Schilling. (Received January 18, 2011)

18 ► Category theory; homological algebra

1068-18-31 **Edgar E. Enochs*** (enochs@ms.uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40506. *Cartan-Eilenberg complexes.* Preliminary report.

In the last chapter of their Homological Algebra Cartan and Eilenberg give definitions of projective and injective resolutions of complexes. These resolutions are certain double complexes. In his thesis Verdier suggested considering these double complexes as complexes whose terms are complexes. Following Verdier's suggestions we define not only Cartan-Eilenberg projective and injective complexes but also such complexes as the Cartan-Eilenberg flat complexes. We then prove that in this relative homological setting there are many Cartan-Eilenberg counterparts of standard results. We also show that every hereditary cotorsion pair in the category of modules gives such a Cartan-Eilenberg pair in the category of complexes of complexes. (Received December 21, 2010)

1068-18-126 **James Gillespie*** (jgillesp@ramapo.edu). *Exact model structures.* Preliminary report.

Exact categories are like abelian categories. They come with short exact sequences but do not necessarily come with all kernels and cokernels. However, they come with enough limits and colimits that one can introduce homotopy theory in the usual way via Quillen model structures. As in the abelian case such model structures correspond to cotorsion pairs and the examples include all the varieties of relative homological algebra that we regularly see. Some interactions between the model structures and the cotorsion pairs with particular emphasis on exact categories will be explored in this talk. (Received January 16, 2011)

1068-18-159 **Walter Tholen*** (tholen@mathstat.yorku.ca), 4700 Keele Street, Toronto, Ontario M3J 1P3, Canada. *Lax Algebra Meets Topology.*

In this talk we combine two research directions, namely the development of a lax-algebraic framework for categories of interest to toplogists and analysts, and the exploration of some key topological concepts, like spartion nad compactness, in an abstract category which comes equipped with an axiomatic notion of "closed" or "proper" map. Hence, we will discuss various candidates for such notions in the context of the category of lax (T,V)-algebras, with a Set-monad T laxly extended to the category of sets and V-valued-relations, for a quantale V. Suitable categories of ordered sets, metric spaces, topological spaces, closure spaces, and approach spaces all fit into this framework. We will give applications of the general topological theory in these contexts.

(Joint work with D. Hofmann.) (Received January 17, 2011)

1068-18-185 **Gavin J Seal*** (gavin.seal@epfl.ch). *Monads, order and topology.* Preliminary report.

Recent progress in monoidal topology. (Received January 18, 2011)

1068-18-238 **Edgar Enochs** (enochs@ms.uky.edu), 719 Patterson Office Tower, Lexington, KY 40506 0027, **Sergio Estrada*** (sestrada@um.es), Campus del Espinardo, 30100 Murcia, Murcia, Spain, and **Alina Iacob** (aiacob@georgiasouthern.edu), Georgia Ave. Room 3008, Statesboro, GA 30460 8093. *Complete cotorsion pairs, model structures and adjoints in homotopy categories.*

We will show the interlacing between complete cotorsion pairs, model structures and the existence of adjoints in homotopy categories. This will give a method of constructing adjoint functors between homotopy categories as well as a method for constructing abelian model structures in the category of unbounded complexes of certain abelian categories. We illustrate our methods by recovering some recents results of Neeman and Murfet as particular instances. And we also find new abelian model structures both in $\mathbb{C}(R)$ and in $\mathbb{C}(\mathfrak{Qco}(X))$ attained to classes which are non necessarily closed under direct limits. (Received January 19, 2011)

1068-18-300 **Dirk Hofmann*** (dirk@ua.pt). *Dualities for distributive spaces.*

Our work with topological spaces presented as convergence structures shaped the idea that *topological spaces are generalised orders*, and eventually revealed the following analogies.

For an ordered set X:	For a topological space X:
down-closed subset	filter of opens
non-empty down-closed subset	proper filter of opens
directed down-closed subset	prime filter of opens
upper bound	limit point
supremum	smallest limit point
cocomplete ordered set	continuous lattice
directed cocomplete ordered set	stably compact space
completely distributive lattice	???
continuous directed cocomplete ordered set	???

In this talk we try to remove the the two question marks above. Furthermore, we show that the category of distributive spaces is dually equivalent to a category of frames by simply observing that both sides represent the idempotent splitting completion of the same category. (Received January 21, 2011)

1068-18-323 **Cyrus F Nourani*** (Akdmkrd@mail.com), PO Box, 109762, San Francisco, CA 94119. *Filters,Fragment Consistent Models, and Preshaves.* Preliminary report.

Proposition 1 There is a natural Gorothedieck topology on the category Lw1,K .

Op Define a functor F : Lw1,K ===> Set to be the generic functor.

1. Define a functor V : D<A,G> ===> Lw1,K by universal embedding from the diagram functions.

Theorem V Creates a limit for F.

From the above we note that there is a contravariant functors Op F : Lw1,K ===> Set to form a presheave.

Lemma The limiting cones that are the basis for small completeness for Lw1,K define example representable presheaves for the objects in Lw1,K .

Theorem The natural transformations on functors sending arbitrary objects to sets on fragment string sets, arrowed by preorder functions, with cones to base F from , on the above on Op the fucntor F, Lw1,K ===> Set, are filter creating representable presheaves for the objects in Lw1,K .

The obvious direction from here is what comma category realizes that above.

. (Received January 20, 2011)

19 ► K-theory

1068-19-309 **Ho Hon Leung*** (hohonleung@math.cornell.edu), Malott Hall 120, Department of Mathematics, Cornell University, Ithaca, NY 14853-4201. *Divided difference operators in Kasparov's equivariant KK-theory.* Preliminary report.

Let G be a compact connected Lie group with maximal torus T. Let A, B be G-C^*-algebras. We define certain divided difference operators on Kasparov's T-equivariant KK-group $KK_T(A, B)$ and show that $KK_G(A, B)$ is a direct summand of $KK_T(A, B)$. More precisely, a T-equivariant KK-class is G-equivariant if and only if it is annihilated by an ideal of divided difference operators. This result is a generalization of work done by Atiyah, and Harada, Landweber and Sjamaar. The talk will include its relation to symplectic geometry. (Received January 19, 2011)

20 ► Group theory and generalizations

1068-20-16 **Thomas Koberda*** (koberda@math.harvard.edu), Department of Mathematics, Harvard University, 1 Oxford St., Cambridge, MA 02138. *Right-angled Artin groups and mapping class groups.*

We will consider subgroups of mapping class groups generated by sufficiently large powers of mapping class groups. The possible isomorphism types of these subgroups can be given in terms of right-angled Artin groups. (Received November 17, 2010)

1068-20-17 **Robert W. Bell*** (rbell@math.msu.edu), W-32 Holmes Hall, Lyman Briggs College, Michigan State University, East Lansing, MI 48825. *Combinatorial methods for detecting hyperbolic surface subgroups of right-angled Artin groups.*

Suppose that C_n is a circuit of length n for some $n \geq 5$. Let $\overline{C}_n$ denote the opposite graph. We give a short proof of the following theorem of Kim: if a graph K contains an induced subgraph isomorphic to $\overline{C}_n$, then the

right-angled Artin group $G(K)$ contains the fundamental group of some closed orientable surface of genus at least two. (Received November 19, 2010)

1068-20-49 **Igor Belegradek*** (ib@math.gatech.edu) and **Chris Hruska**. *Relatively hyperbolic hyperplane complements.*

The talk deals with a family of noncompact aspherical manifolds arising from Riemannian geometry, e.g. the family contains all known examples of complete finite volume Riemannian manifolds of bounded negative sectional curature. Here "bounded negative" means that the curvature is a bounded negative function, which is less restrictive than assuming "pinched negative curvature". The main result gives a criterion under which the manifolds have relatively hyperbolic fundamental groups, and moreover, the criterion supplies enough control on the peripheral subgroups to yield wealth of information about the fundamental groups. (Received January 07, 2011)

1068-20-86 **Jacek Brodzki**, **Graham A. Niblo** and **Piotr W. Nowak*** (pnowak@math.tamu.edu), Department of Mathematics, Texas A&M University, Mailstop 3368 TAMU, College Station, TX 77843, and **Nick J. Wright**. *Exact groups and bounded cohomology.*

A classical theorem due to B.E. Johnson and Ringrose characterizes amenable groups in terms of vanishing of bounded cohomology with coefficients in all dual Banach modules. Exactness is a weak, metric amenability property of groups and Higson asked whether there is a characterization of exact groups in terms of bounded cohomology. In this talk we will answer Higson's question affirmatively. (Received January 13, 2011)

1068-20-93 **Dongwen Qi*** (qi@canes.gsw.edu), Department of Mathematics, Georgia Southwestern State University, 800 GSW State University Drive, Americus, GA 31709. *On the length function of Coxeter groups of type B.* Preliminary report.

We discuss a few formulas or inequalities on the length function of Coxeter groups of type B that explain how the lengths of group elements change along with the Bruhat order. (Received January 14, 2011)

1068-20-96 **Daryl Cooper** and **Jason Manning***, j399m@buffalo.edu. *Counterexamples to a simple loop conjecture for PSL(2,C).*

Minsky asked: Does every non-faithful homomorphism from a closed orientable surface group to PSL(2,C) kill some simple loop? We show that the answer is no by producing examples of non-faithful homomorphisms sending every simple loop either to a non-trivial parabolic or to a loxodromic with non-real trace. (Received January 14, 2011)

1068-20-100 **Gregory McColm*** (mccolm@usf.edu), Department of Mathematics & Statistics, University of South Florida, 4202 E. Fowler Ave., PHY114, Tampa, FL. *Group Theoretic Methods in Nanostructure Design.*

Techniques from geometric group theory and group representation theory are applicable to the automated design of nanostructures and crystalline materials, and we examine one such application. A physical structure may be represented by a Euclidean graph $\mathcal{G}$, with vertices representing components (e.g. atoms, or even molecular building blocks) and edges representing connections (e.g. chemical bonds, or even "linker" molecules that link molecular building blocks). A path through $\mathcal{G}$ may be encoded by a list of (names of) isometries of the Euclidean space, each isometry serving as a vehicle for traveling from one vertex to an adjacent vertex. (In general, the isometries are not necessarily symmetries of $\mathcal{G}$, and successive vertices of a path are not necessarily in the same orbit of $\mathcal{G}$'s symmetry group. But compositions of isometries are required to be symmetries of $\mathcal{G}$ if the path connects two vertices from the same orbit of $\mathcal{G}$'s symmetry group.) The congruence class of $\mathcal{G}$ is fixed by the set of possible paths through $\mathcal{G}$, and using these paths. We look at an algorithm that generates finite or infinite Euclidean graphs. (Received January 14, 2011)

1068-20-123 **Alexander Dranishnikov*** (dranish@math.ufl.edu) and **Mark Sapir**. *On asymptotic dimension of the Thompson group F.*

We show that the Thompson group F has exponential dimension growth. (Received January 17, 2011)

1068-20-162 **A. Yu. Olshanskii*** (alexander.olshanskiy@vanderbilt.edu), 1326 Stevenson Center, Vanderbilt University, Nashville, TN 37240. *Space functions of finitely presented groups.*

To define the space function $s(n)$ of a finitely presented group $G = \langle A \mid R\rangle$ we start with a word w over A of length at most n equal to 1 in G and use relations from R for elementary transformations to obtain the empty word; $s(n)$ bounds from above the tape space one needs to transform any word of length at most n vanishing in G to the empty word. One of the results obtained is the following criterion: A finitely generated group H has

decidable word problem of polynomial space complexity if and only if H is a subgroup of a finitely presented group G with a polynomial space function.
(Received January 17, 2011)

1068-20-200 **Danny Calegari** (dannyc@its.caltech.edu) and **Dongping Zhuang*** (dongping.zhuang@vanderbilt.edu). *Stable W-length.*

Given a subset W of a free group F, a W-word of a group G is the image of some $w \in W$ under some homomorphism $f : F \to G$. Let G_W be the subgroup of G generated by all W-words. G_W is called the verbal subgroup of G. (For example, when $W = [x, y]$, the corresponding verbal subgroup is the commutator subgroup of G.) We study the W-length and stable W-length defined on G_W. A geometric proof of Bavard's duality theorem about stable commutator length will be presented, which will be generalized to a larger class of verbal subgroups. This is a joint work with Danny Calegari. (Received January 18, 2011)

1068-20-308 **Aaron Abrams**, **Noel Brady**, **Pallavi Dani*** (pdani@math.lsu.edu), **Moon Duchin** and **Robert Young** (pdani@math.lsu.edu). *Dehn functions of Bestvina-Brady groups.*

We establish sharp bounds on the higher Dehn functions of Bestvina-Brady groups. This generalizes a result of Brady and a result of Dison on the ordinary Dehn functions of Bestvina-Brady groups. (Received January 19, 2011)

22 ► Topological groups, Lie groups

1068-22-213 **Thomas Baird*** (tbaird@mun.ca). *GKM-sheaves and equivariant cohomology.*

Let T be a compact torus. Goresky, Kottwitz and Macpherson showed that for a large and interesting class of T-equivariant projective varieties X, the equivariant cohomology ring $H^*_T(X)$ is may be encoded in a graph, now called the GKM-graph, with vertices corresponding to the fixed points of X and edges labeled by the weights, $Hom(T, U(1))$.

In this lecture, we explain how the GKM construction can be generalized to any finite T-CW complex. This generalization gives rise to new mathematical objects: GKM-hypergraphs and GKM-sheaves. If time permits, we will show how these methods were used to resolve a conjecture concerning the moduli space of flat connections over a non-orientable surface. (Received January 18, 2011)

1068-22-230 **Gábor Lukács*** (lukacs@cc.umanitoba.ca), Department of Mathematics, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada. *On abelian bornological and topological groups.* Preliminary report.

Let G be an abelian topological group, and let $\hat{G} := \mathcal{H}(G, \mathcal{T})$ denote its group of continuous characters, where $\mathbb{T} := \mathbb{R}/\mathbb{Z}$. Then $\hat{G}$ admits a natural bornology, namely, its subsets that are equicontinuous on G. This is actually a *group bornology* in the sense that it makes the group operations bounded.

Let A be a (discrete) abelian group, $K := \hom(A, \mathbb{T})$, where $\mathbb{T} := \mathbb{R}/\mathbb{Z}$. If H is a subgroup of K and $\mathcal{B}$ is a group bornology on H, then the topology of uniform convergence on members of $\mathcal{B}$ is a group topology on A.

While these constructions are well-known (cf. [1], and [2]), it appears that they have never been investigated from a categorical point of view. The aim of this talk is to remedy this.

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(Received January 18, 2011)

1068-22-233 **James Keesling*** (kees@ufl.edu), **James Maissen** and **David Wilson**. *Topological Group Actions on Compactifications.*

Topological group actions are an important part of many diverse areas of mathematics. Perhaps the most famous problem still standing in this area is the Hilbert-Smith Conjecture which is the last remaining part of Hilbert's Fifth Problem from 1900. The conjecture states that a compact group acting freely on a manifold must be a Lie group.

There are many results related to this famous problem, but none seem close to a solution. This talk will review what is known, some equivalent formulations of the problem, various approaches to the problem, and some recent results.

A novel approach to the problem would be to consider what compactifications can extend an action of a compact group acting on a separable metric space. If one had a compact non-Lie group acting on a compact manifold, then one could look at the action as extending the action on a dense invariant subspace. Knowing how compact group actions extend to compactifications might show how a compact manifold action could be constructed or perhaps why such an action cannot exist.

We will give several examples and theorems. (Received January 19, 2011)

26 ► Real functions

1068-26-4 **Jeremy T. Tyson*** (tyson@math.uiuc.edu), 1409 West Green St., Urbana, IL 61801. *Sobolev mappings into metric spaces.*

The theory of Sobolev functions is by now classical and forms a cornerstone of the modern approach to PDE. Variational problems in differential geometry and geometric function theory motivate extension of the Sobolev theory to nonlinear targets such as Riemannian manifolds and even metric spaces. We will survey recent advances in the theory of metric space-valued Sobolev mappings. Along the way we will encounter several striking results: (a) there exist Sobolev maps from the plane into the first Heisenberg group which cannot be approximated in the Sobolev norm by Lipschitz maps, and (b) every locally compact geodesic metric space is the image of the plane by a continuous map in the Sobolev class $W^{1,2}$. I will indicate why these results are surprising and suggest some future directions for the subject. (Received January 18, 2011)

28 ► Measure and integration

1068-28-50 **Tim Bedford** and **Sergiy Borodachov*** (sborodachov@towson.edu), Department of Mathematics, Towson University, 8000 York Road, Towson, MD 21252, and **Jeff Geronimo**. *A Topological Separation Condition for Fractal Attractors.*

We consider finite systems of contractive homeomorphisms of a complete metric space, which satisfy the minimality property (i.e. are non-redundant on every level). In general this separation condition is weaker than the strong open set condition and is not equivalent to the weak separation property. We prove that this separation condition is equivalent to the strong Markov property. We also show that the set of N-tuples of contractive homeomorphisms, having the minimality property, is a G_δ set in the topology of pointwise convergence of every component mapping with an additional requirement that the supremum of contraction coefficients of mappings in the sequence be strictly less than one. We find a class of N-tuples of $d \times d$ invertible contraction matrices, which define systems of affine mappings in $\mathbf{R}^d$ having the minimality property for almost every N-tuple of fixed points with respect to the Nd-dimensional Lebesgue measure. (Received January 07, 2011)

1068-28-55 **Yang Wang*** (ywang@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824, and **Xinrong Dai** (ywang@math.msu.edu). *Peano Curves for Fractals.*

In 1890 G. Peano introduced a continuous function that maps the unit interval onto the unit square. It is the fi rst construction of a space- filling curve. In 1891 Hilbert discovered another space- filling curve by employing the technique of self-similarity. Later space-filling curves have been constructed by many authors, all of which have the properties that they are Hölder continuous and are measure preserving. A natural question is whether a Peano curve exists for any connected self-similar set. We discuss this question in this talk. (Received January 10, 2011)

1068-28-103 **Hafedh Herichi** (herichi@math.ucr.edu), University of California, Department of Mathematics, Riverside, CA 92521-0135, and **Michel L. Lapidus*** (lapidus@math.ucr.edu), University of California, Department of Mathematics, Riverside, CA 92521-0135. *Fractal strings and a spectral reformulation of the Riemann hypothesis.*

In [1] (J. London Math. Soc.,1995), a spectral reformulation of the Riemann hypothesis was obtained by M.L. Lapidus and H. Maier, involving inverse spectral problems for fractal strings. Later on, this work was revisited in light of the theory of complex dimensions of fractal strings developed by M.L. Lapidus and M. van Frankenhuijsen in [2] (Fractal Geometry and Number Theory, Birkhauser,2000) and [3](Fractal Geometry,Complex Dimensions and Zeta Functions,Springer,2006). Moreover,in [3],the "spectral operator" was introduced as the operator that sends the geometry of a fractal string onto its spectrum. In the present work,we provide a rigorous functional analytic framework for the study of the spectral operator a. We show that a is an unbounded normal operator

acting on a scale of Hilbert spaces (indexed by the Minkowski dimension D in (0,1) of the underlying fractal strings), and precisely determine its spectrum. Furthermore, we deduce that for a given D, the spectral operator is invertible if and only if there are no Riemann zeros on the vertical line Re s = D. It follows that the associated inverse spectral problem has a positive answer for all possible dimensions D in (0,1), other than in the mid-fractal case when D =1/2, if and only the Riemann hypothesis is true. (Received January 14, 2011)

1068-28-175 **De-Jun Feng*** (djfeng@math.cuhk.edu.hk), Department of Mathematics, The Chinese University of Hong Kong, Hong Kong. *Multifractal analysis of Bernoulli convolutions associated with Salem numbers.*

We consider the multifractal structure of the Bernoulli convolution ν_λ, where λ^{-1} is a Salem number in $(1,2)$. Let $\tau(q)$ denote the L^q spectrum of ν_λ. We show that if $\alpha \in [\tau'(+\infty), \tau'(0+)]$, then the level set

$$E(\alpha) := \left\{ x \in \mathbb{R} : \lim_{r\to 0} \frac{\log \nu_\lambda([x-r, x+r])}{\log r} = \alpha \right\}$$

is non-empty and $\dim_H E(\alpha) = \tau^*(\alpha)$, where τ^* denotes the Legendre transform of τ. This result extends to all self-conformal measures satisfying the asymptotically weak separation condition. We point out that the interval $[\tau'(+\infty), \tau'(0+)]$ is not a singleton when λ^{-1} is the largest real root of the polynomial $x^n - x^{n-1} - \cdots - x + 1$, $n \geq 4$. We also construct an example of absolutely continuous self-similar measure μ on $\mathbb{R}$ which has a nontrival multifractal structure. (Received January 18, 2011)

1068-28-256 **Manav Das*** (manav@louisville.edu), 328 Natural Sciences Bldg., Department of Mathematics, University of Louisville, Louisville, KY 40292, and **Gerald A. Edgar** (gerald9edgar@gmail.com), 3091 Mill Vista Rd #1215, Highlands Ranch, CO 80129. *The relationships between separation properties.*

We present some recent results on the relationships between the open set condition, the weak separation condition and the IFS of finite type, for general graph-directed self-similar iterated function systems. (Received January 19, 2011)

1068-28-268 **Katherine Hare** and **Benjamin Steinhurst***, 310 Malott Hall, Department of Mathematics, Cornell University, Ithaca, NY 14850, and **Alexander Teplyaev** and **Denglin Zhou**. *Disconnected Julia sets and gaps in the spectrum of Laplacians on symmetric post-critically finite fractals.*

It is known that Laplacian operators on many fractals have gaps in their spectra. This fact precludes the possibility that a Weyl-type ratio can have a limit and is also a key ingredient in proving that the Fourier series on fractals can have better convergence results than in the classical setting. In this paper we prove that the gaps exist if the Julia set of the spectral decimation function is not connected. (Received January 19, 2011)

1068-28-303 **Michael T. Lacey** (Lacey@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332, **Eric T. Sawyer** (sawyer@mcmaster.ca), Department of Mathematics and Statistics, McMaster University, 1280 Main Street West, Hamilton, Ontario L8S 4K1, Canada, **Xavier Tolsa** (xtolsa@mat.uab.cat), Departament de Matematiques, Universitat Autonoma de Barcelona, 08193 Bellaterra, Spain, and **Ignacio Uriarte-Tuero*** (ignacio@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824. *Fractals yielding extremal examples in some problems in harmonic and complex analysis.*

I will report on some Cantor type sets that have provided extremal examples in problems related to quasiconformal maps and harmonic analysis.

More precisely, Astala et al. [Duke, 2008] asked whether BMO and L^∞ removability were the same problem for planar K-quasiregular maps. A non-self-similar Cantor set provided a negative answer [UT, IMRN 2008]. The same example further proved the sharpness of a conjecture of Astala from 1994 (later proved by Lacey, Sawyer, and UT [Acta, 2010]).

The same type of example further proved the sharpness of a metric condition for removability for bounded K-quasiregular maps [Tolsa, UT].

A related problem (though at first sight very different) pertains to characterizing pairs of weights (u, v) for which the Hilbert transform is bounded $L^2(u) \to L^2(v)$. A conjecture was made in a seminal paper by Nazarov, Treil and Volberg that a certain pivotal condition was necessary. Such conjecture was disproved by Lacey, Sawyer and UT using a Cantor set example.

The talk will be self-contained. (Received January 19, 2011)

1068-28-304 **Jasun Gong*** (jasun@pitt.edu), 301 Thackeray Hall, University of Pittsburgh, Pittsburgh, PA 15260. *Structure theory of metric currents on Euclidean spaces.* Preliminary report.

The notion of a current dates back to de Rham (1955) and a ground-breaking structure theory was developed by Federer and Fleming in the 1960s. Roughly speaking, currents form a dual space to the class of compactly-supported differential forms on Euclidean spaces.

In recent years, Ambrosio and Kirchheim (2000) and Lang (2007) developed theories of currents that are well-defined in the setting of metric spaces. In this talk we discuss the structure theory of such "metric currents" in Euclidean spaces, address progress towards a few open problems, and if time permits, indicate the connections betweeen this theory and the structure of Lebesgue null sets in Euclidean spaces. (Received January 19, 2011)

30 ► Functions of a complex variable

1068-30-47 **James T Gill*** (gill@math.washington.edu), University of Washington, Department of Mathematics, Box 354350, Seattle, WA 98195, and **Steffen Rohde**. *On the Riemann surface type of Random Planar Maps.*

We show that the (random) Riemann surfaces of the Angel-Schramm Uniform Infinite Planar Triangulation and of Sheffield's infinite necklace construction are both parabolic. In other words, Brownian motion on these surfaces is recurrent. We obtain this result as a corollary to a more general theorem on subsequential distributional limits of random unbiased disc triangulations, following work of Benjamini and Schramm. (Received January 06, 2011)

1068-30-51 **Andrew Lorent*** (lorentaw@uc.edu), Mathematics Department, University of Cincinnati, Cincinnati, OH. *Functions whose symmetric part of gradient agree and a generalization of Reshetnyak's compactness Theorem.*

Abstract. Rigidity of functions whose gradient lies in a subject of the conformal matrices is a classic subject, the one of the earliest theorems being Liouville's Theorem that conformal mappings in R^3 are either affine or Mobius. There has been extensive work on developing a quantitative generalization of this result, one of the best known theorems has been Reshetnyak's compactness theorem that say if u_n is a weakly converging sequence in $W^{1,1}$ and $\int dist(Du, SO(n))dx- > 0$ then u_n convergence strongly in $W^{1,1}$ to an affine map whose gradient is a rotation. We reformulation this theorem as a special case of the question: What happens when to two sequences of functions that have increasingly similar symmetric part of gradient? We will provide a sharp answer to this question and consequently present a broad generalization of Reshetnak's theorem. (Received January 07, 2011)

1068-30-65 **Zoltán M. Balogh** and **Katrin Fässler*** (katrin.faessler@math.unibe.ch), Department of Mathematics, Sidlerstrasse 5, 3012 Bern, Switzerland, and **Ioannis D. Platis**. *Extremal quasiconformal mappings on the Heisenberg group.* Preliminary report.

We employ the modulus of curve families in order to identify mappings with smallest possible distortion within a given class of quasiconformal mappings on the Heisenberg group. We study both minimizers for the maximal and for a weighted mean distortion. This method can be applied to detect Heisenberg counterparts of classical extremal quasiconformal mappings in the complex plane. (Received January 11, 2011)

1068-30-120 **Pekka Pankka*** (pekka.pankka@helsinki.fi), P.O. Box 68 (Gustaf Hällströmin katu 2b), 00014 Helsinki, Finland, and **Juan Souto**. *Non-existence of certain branched covers.*

In geometric mapping theory, closed manifolds receiving quasiregular mappings from an Euclidean n-space is an intriguing class of non-hyperbolic manifolds. All known examples of manifolds of this type are obtained by explicit constructions using branched covering mappings from tori.

I will discuss how the maximal de Rham cohomology in some intermediate dimension of the target manifold prevents an existence of a branching branched covering map from a torus of the same dimension. This result rules out the possibility of having a Rickman type example of a quasiregular mapping from the $\mathbb{R}^4$ to connected sum of three copies of $S^2 \times S^2$ that factors through the 4-torus. This is joint work with Juan Souto. (Received January 16, 2011)

1068-30-133 **David M Freeman*** (david.freeman@uc.edu), University of Cincinnati, Raymond Walters College, 9555 Plainfield Rd, Cincinnati, OH 45236. *Bilipschitz Homogeneous Surfaces.*

In this talk we shall discuss geometric properties of bilipschitz homogeneous (geodesic) surfaces and some connections with the problem of characterizing the Euclidean plane up to bilipschitz maps. (Received January 16, 2011)

1068-30-215 **Hrant Hakobyan*** (hakobyan@math.ksu.edu), 138 Cardwell Hall, Department of Mathematics, Manhattan, KS 66502. *Modulus estimates in slit carpets and Menger curves.* Preliminary report.

Upper bounds are obtained for moduli of curve families in "slit carpets" first studied by Merenkov. Some applications of these bounds are:

(1) There are QS co-Hopfian spaces homeomorphic to the Menger curve (answers a question of Merenkov);

(2) A sufficient condition for the failure of the Poincare Inequality in non self-similar slit carpets.

For (1) we construct explicit admissible metrics, which can be generalized to any dimension and work without the assumption of self-similarity. Condition (2) is similar to the one obtained by MacKay, Tyson and Wildrick in the case of non self-similar square carpets and its proof uses conformal mappings (hence does not generalize to $\mathbb{R}^n, n \geq 3$). We think this condition is sharp. (Received January 18, 2011)

1068-30-225 **Mishko Mitkovski***, 7301 Chastain Dr., Atlanta, GA 30342. *Results in harmonic analysis.* Preliminary report.

We shall report on recent work with collaborators. (Received January 18, 2011)

1068-30-244 **Shanshuang Yang*** (syang@mathcs.emory.edu), Department of Math and CS, Emory University, 400 Dowman Drive, Atlanta, GA 30322. *Rigidity of Quasiconformal Embeddings.* Preliminary report.

A classical Liouville type theorem asserts that an orientation preserving embedding of the plane $f : \mathbb{C} \to \mathbb{C}$ is 1-quasiconformal (or 1-QC) if and only if it is a linear map: $f(z) = az + b$. A sophisticated version of this result in higher dimensions states that if D is a domain in the Euclidean space $\mathbb{R}^n$ ($n \geq 3$), then an embedding $f : D \to \mathbb{R}^n$ is 1-QC if and only if it is the restriction of a Möbius transformation. In this talk we will discuss the possibilities of generalizing this type of rigidity results to embeddings of a domain $D \subset \mathbb{R}^n$ into a higher dimensional space $\mathbb{R}^m$ (with $m > n$). (Received January 19, 2011)

1068-30-295 **Marshall C. Williams*** (mcwill@uic.edu). *Analytic inverse quasiregularity and Poletsky's inequality.* Preliminary report.

We introduce a definition of "analytic inverse quasiregularity" for a discrete open mapping $f\colon X \to Y$ between locally compact metric measure spaces. This definition turns out to be equivalent to Poletsky's inequality (the "K_I-inequality"). As an application, we prove that if X and Y are Ahlfors Q-regular, then the metric definition of quasiregularity implies our analytic inverse definition. This then proves Poletsky's inequality, generalizing a result of Onninen and Rajala, who proved the inequality when X is a domain in $\mathbb{R}^n$ and Y is an n-regular cohomology manifold. (Received January 19, 2011)

1068-30-311 **Michael T. Lacey** (Lacey@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332, **Istvan Prause** (istvan.prause@helsinki.fi), P.O. Box 68 (Gustaf Hällströmin katu 2b), University of Helsinki, FI-00014 Helsinki, Finland, **Eric T. Sawyer** (sawyer@mcmaster.ca), Department of Mathematics and Statistics, McMaster University, 1280 Main Street West, Hamilton, Ontario L8S 4K1, Canada, **Xavier Tolsa** (xtolsa@mat.uab.cat), Departament de Matematiques, Universitat Autonoma de Barcelona, 08193 Bellaterra, Barcelona, Spain, and **Ignacio Uriarte-Tuero*** (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 January 19, 2011)

32 ► Several complex variables and analytic spaces

1068-32-2 **Brett D. Wick*** (wick@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, 686 Cherry Street, Atlanta, GA 30332-1060. *The Corona Problem.*

Carleson's Corona Theorem from the 1960's has served as a major motivation for many results in complex function theory, operator theory and harmonic analysis. In a simple form, the result states that for N bounded analytic functions $f_1, \ldots, f_N$ on the unit disc such that $\inf |f_1| + \cdots + |f_N| \geq \delta > 0$ it is possible to find N other bounded analytic functions $g_1, \ldots, g_N$ such that $f_1 g_1 + \cdots + f_N g_N = 1$. Moreover, the functions $g_1, \ldots, g_N$ can be chosen with some norm control.

In this talk we will discuss some generalizations of this result to certain vector valued functions and connections with geometry and to function spaces on the unit ball in several complex variables. (Received January 17, 2011)

1068-32-169 **S. Merenkov** (merenkov@illinois.edu) and **K. Wildrick*** (kevin.wildrick@jyu.fi), Matematiikan ja Tilastotieteen Laitos, Jyväskylän Yliopisto, 40200 Jyväskylä, Finland. *Quasisymmetric Koebe Uniformization.* Preliminary report.

In 1909, Koebe conjectured that every domain in $\mathbb{S}^2$ is conformally equivalent to a circle domain, i.e., a domain whose complementary components are points and round disks. The conjecture was confirmed for finitely connected domains by Koebe in the 1920's, and in the countable case 70 years later by He and Schramm. Motivated by the Kleiner-Kapovich conjecture in geometric group theory, we present a quasisymmetric version of Koebe's conjecture in the general metric setting. We prove a positive result under natural conditions and provide an example showing sharpness in some respects. (Received January 17, 2011)

34 ► Ordinary differential equations

1068-34-166 **Nuriye Atasever*** (na00487@georgiasouthern.edu) and **Billur Kaymakcalan** (billur@georgiasouthern.edu). *Basics of Diamond-Alpha Dynamic Equations and Inequalities.* Preliminary report.

Basic calculus properties of diamond-alpha dynamic equations, which are convex combinations of delta and nabla dynamic equations are given and their importance and advantages are illustrated with some examples. A survey of recent works in this area are also given. This is Part-I of a joint work with Billur Kaymakcalan. (Received January 17, 2011)

1068-34-189 **Gangaram S. Ladde*** (gladde@usf.edu), Department of Mathematics and Statistics, University of South Florida, 4202 East Fowler Avenue, PHY 114, Tampa, FL 33620-5700, and **Jinghan Meng**. *ENERGY FUNCTION AND STOCHASTIC DIFFERENTIAL UNDER MULTI-SCALES.* Preliminary report.

By utilizing energy like functions several comparison results are developed. The obtained results applied to study the qualitative behavior of stochastic differential equations under multiple time scales. (Received January 18, 2011)

1068-34-263 **Jeffrey T Neugebauer*** (jeffrey_neugebauer@baylor.edu), Department of Mathematics, Baylor University, One Bear Place #97328, Waco, TX 76798-7328. *Fixed point theorem of Leggett-Williams Type for a right focal boundary value problem on a time scale.*

An application is made of a new fixed point theorem in the spirit of the original fixed point work of Leggett and Williams, to obtain positive solutions of the second order right focal boundary value problem on a time scale. An example is then provided. (Received January 19, 2011)

1068-34-277 **M. Sambandham*** (msambband@morehouse.edu), Department of Mathematics, Atlanta, GA 30314. *Comparison theorem and stability results for hybrid fractional time scale systems.*

We will develop a comparison theorem for hybrid fractional time scale systems and apply it to find stability properties of such systems (Received January 19, 2011)

1068-34-322 **Ralph W. Oberste-Vorth*** (oberstevorth@marshall.edu), Department of Mathematics, 1 John Marshall Drive, Huntington, WV 25755. *The Hausdorff-Fell Topology on Time Scales and the Convergence of Solutions of Dynamic Equations.*

We present the Hausdorff-Fell topology on the set of all time scales. In that context, we examine the convergence of solutions of dynamic equations on time scales: consider sequences of dynamic initial value problems

$$x_n^{\Delta} = f_n(t, x), \quad x_n(t_{0,n}) = x_{0,n}$$

over time scales $\mathbb{T}_n$, where the time scales $\mathbb{T}_n$, the functions f_n, and the initial conditions $(t_{0,n}, x_{0,n})$, converge to a time scale $\mathbb{T}$, a function f, and (t_0, x_0), respectively. We verify the convergence of subsequences $x_{n_k}(t)$ of solutions of these initial value problems to a solution of the limit problem

$$x^{\Delta} = f(t, x), \quad x_n(t_0) = x_0.$$

Much of this is joint work with B. Lawrence. (Received January 20, 2011)

1068-34-328 **Billur Kaymakcalan*** (billur@georgiasouthern.edu) and **Nuriye Atasever**. *Opial type Diamond-Alpha Dynamic Inequalities and Applications.* Preliminary report.

In view of the recently developed diamond-alpha dynamic derivatives and integrals, which are convex combinations of the corresponding delta and nabla concepts, Opial type inequalities are given along with applications to boundary value problems. (Received January 20, 2011)

1068-34-332 **Bonita A. Lawrence*** (lawrence@marshall.edu), Department of Mathematics, One John Marshall Drive, Huntington, WV 25755-2560, **Clayton T. Brooks** (brooksc@marshall.edu), Department of Mathematics, One John Marshall Drive, Huntington, WV 25755-2560, and **Richard P. Merritt** (merritt37@marshall.edu), Department of Mathematics, One John Marshall Drive, Huntington, WV 25755-2560. *The Marshall Differential Analzyer Project: Dynamics in Motion.*

Mechanical differential analyzers, used as early as the late 1920's, were the first computers for solving nonlinear differential equations. A resurgence of interest in these machines for the purposes of studying the qualitative behavior of dynamic equations began a few years ago at Marshall University. There a team of undergraduate and graduate students first constructed a small two integrator machine, designed to handle linear differential equations, and then built a much larger four integrator machine, equipped to solve both linear and nonlinear differential equations. Currently the machines are being used to study the qualitative behavior of certain classes of differential equations. In this presentation I will give a bit of history of the project, discuss how the mechanics of the machine models the mathematics, and give a demonstration with our small traveling model we call Lizzie. (Received January 20, 2011)

35 ► Partial differential equations

1068-35-24 **Fedor Nazarov**, **Alexander B Reznikov*** (reznikov@ymail.com), **Vasily Vasyunin** and **Alexander Volberg**. *"Monge-Ampere equations and Bellman functions related to A_1-conjecture.*

Recently Maria Reguera disproved the famous Muckenhoupt-Wheeden conjecture related to Calderon-Zygmund operators. Soon after that the weak version of it was disproved by means of Bellman Function. The certain Monge-Ampere equation was used to disprove it.

We shall talk about several Monge-Ampere equations which arise in the problem and point out some unusual things that were investigated in this proof. (Received December 13, 2010)

1068-35-37 **J. E. Lin*** (jelin@gmu.edu), 4400 University Drive, Fairfax, VA 22030. *Local Time Decay for a Quasilinear Schrödinger Equation.*

We study the solutions of a quasilinear Schrödinger equation which arises in many area of physical modeling. Using the Morawetz Radial Identity, we show that the energy is locally integrable in time and the local L2-norm of the solution decays to zero as time approaches infinity. (Received December 30, 2010)

1068-35-59 **Nathan Kirk Pennington*** (npenning@ksu.edu), 138 Cardwell Hall, Manhattan, KS 66506-2602. *Local and global existence of solutions to the Lagrangian Averaged Navier-Stokes equations with weak initial data.*

The Lagrangian Averaged Navier-Stokes equations are a recently derived approximation to the Navier-Stokes equations. As the name suggests, the Lagrangian Averaged Navier-Stokes are derived by averaging at the Lagrangian level, and the resulting PDE has better controlled long time behavior than the Navier-Stokes equations. In this talk, we seek low regularity, local solutions to the Lagrangian Averaged Navier-Stokes equations with initial data in Sobolev and Besov spaces. The principal obstacle to overcome here is the presence of a nonlinear term in the Lagrangian Averaged Navier-Stokes equations that is not present in the Navier-Stokes equations. In the special case of L^2 Sobolev and Besov spaces, we exploit the improved long time behavior of the Lagrangian Averaged Navier-Stokes equations to extend our local solutions to global solutions. (Received January 10, 2011)

1068-35-61 **William Green***, 600 Lincoln Ave., Charleston, IL 61920. *Dispersive estimates for matrix and scalar Schrödinger operators in dimension five.*

We study the non-selfadjoint matrix Schrödinger operator

$$\mathcal{H} = \begin{bmatrix} -\Delta + \mu - V_1 & -V_2 \\ V_2 & \Delta - \mu + V_1 \end{bmatrix}$$

in dimension five. This operator arises when linearizing about standing wave solutions in certain non-linear partial differential equations. Here $\mu > 0$ and V_1, V_2 are real-valued decaying potentials. We examine the boundedness of the evolution operator $e^{it\mathcal{H}}$ in the sense of $L^1 \to L^\infty$.

We prove $L^1 \to L^\infty$ dispersive estimates for the matrix operator that are analogous to the known estimates for the evolution of the scalar Hamiltonian $H = -\Delta + V$. We show that if P_c is projection away from the eigenvalues of $\mathcal{H}$, along with standard assumptions on the spectrum of $\mathcal{H}$,

$$\|e^{it\mathcal{H}} P_c\|_{1\to\infty} \lesssim |t|^{-5/2}$$

holds with optimal assumptions on regularity of the potentials. We further discuss an improvement on the decay assumptions for the scalar case. (Received January 10, 2011)

1068-35-77 **Carlos Almada*** (almada_carlos@colstate.edu), 4225 University Ave., Department of Mathematics, Columbus State University, Columbus, GA 31907. *Decay Rates for the Shifted Wave Equation on a Symmetric Space of Noncompact type.*

In this work we derive $L^\infty - L^1$ decay rate estimates for solutions of the shifted wave equation on certain symmetric spaces (M, g). Helgason study the Cauchy problem for the wave operator $\mathcal{L} = \partial^2/\partial t^2 - \Delta - c^2$ on these spaces and obtained a closed form for the solution. We extend to this new context the classical estimates for the wave equation in $\mathbb{R}^n$. Then, following some ideas of Klainerman, we introduce a new norm based on Lie derivatives with respect to Killing fields on M and derive an estimate for the case when $n = \dim M$ is odd. (Received January 12, 2011)

1068-35-78 **Junfang Li** (jli@math.uab.edu), Department of Mathematics, University of Alabama at Birmingham, Birmingham, AL 35294, and **Xiangjin Xu*** (xxu@math.binghamton.edu), Department of Mathematical Sciences, Binghamton University-SUNY, Binghamton, NY 13902-6000. *Li-Yau type gradient estimates and monotonicity of entropy formulas on complete Riemmannian manifolds with negative Ricci curvature.*

We study the new Li-Yau type gradient estimates, and new differential Harnack inequality for the positive solutions of the linear heat equation on complete Riemannian manifolds with $Ricci(M) \geq -K$ with $K \geq 0$. And we also prove that the corresponding entropy for the linear heat equation on complete Riemmannian manifolds with Ricci curvature bounded from below is monotone decreasing. As applications, several parabolic Harnack inequalities are obtained and they lead to new estimates on heat kernels of manifolds with Ricci curvature bounded from below. (Received January 12, 2011)

1068-35-88 **Chunshan Zhao*** (czhao@georgiasouthern.edu). *Asymptotic Behaviors of Solutions to a Class of N-Laplacian Elliptic Equations.*

I will talk about some asymptotic behaviors of positive solutions to a class of elliptic equations related to N-Laplacian as the diffusion coefficient changes. Results for a couple of cases will be presented. (Received January 14, 2011)

1068-35-102 **Xianpeng Hu*** (xianpeng@cims.nyu.edu), Courant Institute of Mathematical Sciences, New York University, New York, NY 10012. *Global well-posedness for compressible viscoelastic fluids.*

The global well-posedness of strong solutions for compressible viscoelastic fluids is considered in the framework of critical spaces. The solution is close to an equilibrium. The decays in time for the unknown functions are also obtained. (Received January 14, 2011)

1068-35-107 **Hongjie Dong*** (hongjie_dong@brown.edu), 182 George Street, Providence, RI 02912. *Elliptic equations in polygonal domains with discontinuous coefficients.*

I shall present some recent results about the W^2_p estimate up to the boundary for second-order elliptic equations in polygonal domains with discontinuous leading coefficients. (Received January 15, 2011)

1068-35-110 **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 1D Vlasov-Poisson 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 $\left(s < \frac{3}{2}\right)$ Sobolev norm of the distribution function. Therefore, the nonlinear Landau damping is NOT true in H^s $\left(s < \frac{3}{2}\right)$ spaces. We also showed that in small H^s $\left(s > \frac{3}{2}\right)$ 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 $\left(s > \frac{3}{2}\right)$ 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 January 15, 2011)

1068-35-113 **Konstantin I. Oskolkov*** (kooskolkov@gmail.com), Department of Mathematics, University of South Carolina, Columbia, SC 29208. *On Riemann - Schrödinger function.*

Multi-fractal properties of the function

$$\Phi : \mathbb{R}^2 \mapsto \mathbb{C}, \quad \Phi(t,x) := \sum_{n \in \mathbb{Z}\setminus\{0\}} \frac{e^{\pi i (tn^2 + 2xn)}}{\pi i n^2}$$

will be discussed. It seems natural to name Φ *Riemann – Schrödinger function* because: 1) the real part of the restriction of Φ onto the line $x = 0$ coincides with the famous function that was proposed by B. Riemann as *plausible* example of a continuous but nowhere differentiable function, and 2) Φ is a generalized solution of the Schrödinger equation of a free particle, $(4\pi i \partial_t - \partial_x^2)\Phi = 0$. The properties of Φ, particularly those of its' partial derivative $\partial_x \Phi$ have implications in analytic number theory – all *incomplete Gauss' sums* are "encoded" in this derivative. (Received January 15, 2011)

1068-35-127 **Yulia Karpeshina*** (karpeshi@uab.edu), Department of Mathematics, UAB, 1300 University blvd, Birmingham, AL 35294-1170, and **Young-Ran Lee** (younglee@sogang.ac.kr), Department of Mathematics, Sogang University, Seoul, South Korea. *KAM method and Spectral Properties of the Limit-Periodic Schroedinger Operator in Dimension Two.*

We consider the application of KAM (Kolmogorov-Arnold-Moser) method for spectral investigation of the Schroedinger operator $H = -\Delta + V(x)$ with a limit-periodic potential $V(x)$ in dimension two. We prove that the spectrum of H contains a semiaxis and there is a family of generalized eigenfunctions at every point of this semiaxis with the following properties. First, the eigenfunctions are close to plane waves $e^{i\langle \vec{k}, \vec{x}\rangle}$ at the high energy region. Second, the isoenergetic curves in the space of momenta $\vec{k}$ corresponding to these eigenfunctions have a form of slightly distorted circles with holes (Cantor type structure). (Received January 16, 2011)

1068-35-129 **Benoit Pausader*** (benoit.pausader@math.brown.edu). *The energy-critical Schrodinger equation in the hyperbolic space.*

We will prove that solutions to the defocusing energy-critical Schrodinger equations are global in the hyperbolic space H^3. The relevance of the energy-critical case is that in this case, one needs to understand how to take into account the scaling limits of the equation. In particular, one needs to see how to connect solutions to the corresponding equation on a Euclidian space to solutions of the original equation which concentrate as they evolve. This is a joint work with A. Ionescu and G. Staffilani. (Received January 16, 2011)

1068-35-137 **Svitlana Mayboroda***, svitlana@math.purdue.edu. *Well-posedness of boundary problems for elliptic operators with complex bounded measurable coefficients.*

I will discuss the questions of well-posedness in L^p for regularity, Dirichlet, and Neumann problems associated to elliptic operators with complex bounded measurable coefficients. In particular, I will prove that the solvability of the regularity problem does not imply the solvability of the dual Dirichlet problem for general elliptic operators with complex bounded measurable coefficients. This is strikingly different from the case of real operators, for which such an implication was established in 1993 by C.Kenig, J. Pipher [Invent. Math. 113] and since then has served as an integral part of many results. (Received January 17, 2011)

1068-35-148 **Hans Christianson*** (hans@math.unc.edu), Department of Mathematics, UNC-Chapel Hill, CB#3250 Phillips Hall, Chapel Hill, NC 27599, and **Jared Wunsch**. *Local smoothing with a prescribed loss for the Schrodinger equation.*

Local smoothing estimates express that, on average in time and locally in space, solutions to the Schrödinger equation are more regular than the initial data. It is known that the presence of trapped geodesics forces a loss in the local smoothing effect, but not too many examples have been studied. In this work, we study some

examples which fill in the gap between no loss and total loss in the smoothing effect. (Received January 17, 2011)

1068-35-150 **Ronald E. Mickens*** (rohrs@math.gatech.edu), Clark Atlanta University, Physics Department, Atlanta, GA 30314, and **Kale Oyedeji** (koyedeji@morehouse.edu), Morehouse College, Atlanta, GA 30314. *The Methodology of the Construction of SIR Models for the Spread of Disease.*

The standard SIR model, for the spread of a disease, gives a mathematical representation of the conversion of members of the susceptible population to the infective population, and then the subsequent transition of infectives to the removed class. In general, it is assumed that the transition or interaction terms are expressible as integer valued polynomials of the relevant variables. However, there does not exist any *a priori* rules which require that this is the proper mathematical structure for such terms. In this work, we introduce the principal of "dynamic consistency" (DC) and demonstrate how its application can produce SIR models that are in better agreement with the known epidemiological data. Consistent with the principal of DC, we construct a new SIR model that has the feature that its exact, explicit solution can be found. Finally, we examine the generic properties of a SIR model having population growth and contrast its solutions with models not having this characteristic. (Received January 17, 2011)

1068-35-161 **Justin Holmer** and **Svetlana Roudenko*** (roudenko@gwu.edu), Department of Mathematics, The George Washington University, Washington, DC 20052. *On the blow up behavior of solutions to the focusing nonlinear Schroedinger equation.*

We study blow-up solutions to the focusing NLS equations in the mass-critical and mass-supercritical cases, and discuss dynamics of such solutions. In particular, we show that the log-log blow-up solutions to the mass-critical equation, studied by Merle-Raphael, remain regular in the energy space away from the blow-up point. This implies, for example, that there exist H^1 radial blow-up solutions on a sphere for the 3d quintic (energy-critical) NLS equation, thus, improving the result of Raphael-Szeftel (2008). (Received January 17, 2011)

1068-35-179 **Gregory C. Verchota***, Dept. Mathematics, 215 Carnegie Hall, Syracuse, NY 13244. *Linear elliptic operators with constant coefficients require nonconstant coefficient Dirichlet forms for the coercive estimate.*

A linear homogeneous 4th order elliptic differential operator L with real constant coefficients and a bounded nonsmooth convex domain Ω are constructed in $\mathbb{R}^6$ so that L has no constant coefficient coercive integro-differential quadratic form over the Sobolev space $W^{2,2}(\Omega)$. A nonconstant coefficient coercive form for L is not known. (Received January 18, 2011)

1068-35-187 **David Cruz-Uribe SFO** and **Cristian Rios*** (crios@ucalgary.ca), Department of Mathematics, 2500 University Drive NW, Calgary, AB T2N 1N4, Canada. *The Kato problem for A_2-elliptic operators.*

We establish the Kato square root conjecture, $\|\mathcal{L}_w^{\frac{1}{2}} f\|_{L^2(w)} \approx \|\nabla f\|_{L^2(w)}$ for the elliptic operator $\mathcal{L}_w = -w^{-1}\mathrm{div}\mathbf{A}\nabla$, where the $\mathbf{A}$ is a degenerate elliptic matrix whose degeneracies are controlled by the weight $w \in A_2$. We first establish the analogous result for higher order elliptic operators such that kernels of the associated semigroups satisfy Gaussian bounds. We then apply an interpolation result due to Kato to use this fact to prove the desired result. (Received January 18, 2011)

1068-35-190 **Katharine A Ott*** (katharine.ott@uky.edu), 715 Patterson Office Tower, Lexington, KY 40506, and **Russell Brown** and **Justin Taylor**. *Mixed boundary value problems in Lipschitz domains.*

In this talk I will discuss recent progress in the study of mixed boundary value problems for elliptic equations in bounded Lipschitz domains. This is joint work with Justin Taylor and Russell Brown. (Received January 18, 2011)

1068-35-193 **Andrzej Swiech*** (swiech@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, 686 Cherry Street, Atlanta, GA 30332, and **Jerzy Zabczyk** (J.Zabczyk@impan.pl), Institute of Mathematics, Polish Academy of Sciences, Sniadeckich 8, 00-950 Warsaw, Poland. *Large deviations for stochastic PDE with Lévy noise.*

We will present a large deviation principle result for solutions of abstract stochastic evolution equations perturbed by small Lévy noise. The result is obtained by a combination of PDE and probabilistic techniques. The key component of this approach is the use of Hamilton-Jacobi-Bellman integro-partial differential equations in Hilbert spaces. We will discuss the notion of viscosity solutions for such infinite dimensional integro-PDE. Our results

are very general and apply for instance to stochastic hyperbolic equations perturbed by subordinated Wiener process. (Received January 18, 2011)

1068-35-194 **Xiaosheng Li*** (xli@fiu.edu), Department of Mathematics and Statistics, Florida International University, Miami, FL 33199. *Inverse Boundary Value Problems in a Slab.*

In this work we consider the inverse boundary value problems for Schroedinger equations with Yang-Mills potentials in the domain of infinite slab type. We prove that the potentials can be determined uniquely up to a gauge equivalent class, assuming that only partial measurements are known on the boundary hyperplanes. (Received January 18, 2011)

1068-35-205 **Gideon Simpson*** (simpson@math.toronto.edu), 40 St. George Street, Room 6290, Toronto, ON M5S2E4, Canada. *Eigenvalues of matrix Hamiltonains arising from the nonlinear Schrödinger equation.*

We study the spectral properties of matrix Hamiltonians generated by linearizing the nonlinear Schrödinger equation about soliton solutions. Such spectral information on the operators is neccessary to complete results on the asymptotic stability of the solitons. Using a hybrid analytical-numerical proof, we show that there are no purely imaginary eigenvalues in the spectrum of the JL linear operator for a collection 1D and 3D orbitally unstable problems, including the cubic-quintic equation. This work reveals the limits of this strategy of proof: we succeed for some supercritical 1D and 3D problems, but not all. We speculate on this failure and ways it may be extended.

This is joint work with J. L. Marzuola (University of North Carolina – Chapel Hill) and R. Asad (University of Toronto). (Received January 18, 2011)

1068-35-241 **Erwin Suazo*** (erwin.suazo@upr.edu), University of Puerto Rico, Department of Mathematics Call Box 9000, Mayagüez, PR 00681-900. *Method of separation of variables for Schrödinger equation with time-dependent quadratic Hamiltonians.* Preliminary report.

We will discuss applications of the method of separation of variables in the study of linear and nonlinear Schrödinger equations with quadratic time-dependent Hamiltonians. In the latter we construct soliton-like solutions for certain choices of the coefficients, including important examples such as bright and dark solitons and Jacobi elliptic and second Painlevé transcendental solutions, which are important for current research in nonlinear optics and Bose–Einstein condensation. In the linear case we are able to construct the fundamental solution explicitly. We will give several examples inspired from solvable cases of the Riccati equation and emphasize an example envolving Airy functions. A large part of the results presented have been done in joint work with Sergei K. Suslov. (Received January 19, 2011)

1068-35-246 **M Burak Erdogan*** (berdogan@math.uiuc.edu), Department of Mathematics, University of Illinois, Urbana, IL 61801, and **Vadim Zharnitsky** and **Nikos Tzirakis**. *Near-linear behavior in periodic KdV.*

In this talk we will discuss recent results on the high energy solutions of periodic KdV equation. (Received January 19, 2011)

1068-35-251 **Zhongyi Nie** and **Russell M. Brown*** (russell.brown@uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40506 0027. *Estimates for a family of multi-linear forms.*

We consider a family of n-linear forms and establish uniform estimates as n increases. We apply these estimates to study a scattering map that arises in several contexts including the inverse conductivity problem and the solution of one of the Davey-Stewartson equations by the method of inverse scattering. (Received January 19, 2011)

1068-35-264 **Yujin Guo*** (yjguo@math.umn.edu), School of Math., University of Minnesota, 127 Vincent Hall, 206 Church St. SE, Minneapolis, MN 55455. *Singular Wave Equations Arising in Electrostatic MEMS.*

We discuss various qualitative properties of dynamical and stationary solutions of a singular wave equation with an inverse-square type nonlinearity. Such an equation models a simple electrostatic Micro-Electromechanical System (MEMS) device, which consists of a thin dielectric elastic membrane with boundary supported above a rigid ground plate. When a voltage is applied, the membrane deflects towards the ground plate, and a snap-through (i.e. quenching) may occur when the applied voltage exceeds a certain critical value. (Received January 19, 2011)

1068-35-269 **Christof – Sparber*** (sparber@uic.edu). *Multiphase geometric optics for nonlinear Schroedinger equations.*

We consider the cubic nonlinear Schoedinger equation in a weakly nonlinear semiclassical scaling and analyze the interaction of highly oscillatory waves within this context. An extension to the Davey-Stewartson system will also be discussed. This is based joint works with R. Carles and E. Dumas. (Received January 19, 2011)

1068-35-275 **Yanni Zeng***, Department of Mathematics, University of Alabama at Birmingham, Birmingham, AL 35294. *Nonlinear Stability and Large Time Behavior of Viscous Shock Wave with Physical Viscosity.*

This is a joint work with T.-P. Liu. We consider a general hyperbolic-parabolic system of conservation laws. Physical examples include the Navier-Stokes equations for compressible fluids and the equations of magnetohydrodynamics. We study the nonlinear stability of viscous shock waves and large time behavior of solutions. Under the basic Kawashima-Shizuta type assumptions we show that the solution of the Cauchy problem approaches to a particular translated shock profile at large time. Detailed information on the convergence is obtained. This includes optimal convergence rates in space and in time, together with explicit dependence on the shock strength. Our result recovers the optimal result for constant state perturbation as the shock strength tends to zero. (Received January 19, 2011)

1068-35-286 **Gung-Min Gie*** (gungmin@ucr.edu), Department of Mathematics, University of California, Riverside, 900 University Ave., Riverside, CA 92521, and **James P. Kelliher** (kelliher@math.ucr.edu), Department of Mathematics, University of California, Riverside, 900 University Ave., Riverside, CA 92521. *Boundary layers for the Navier-Stokes equations with the Navier friction boundary conditions.* Preliminary report.

We study the "weak" boundary layer phenomenon of the Navier-Stokes equations, supplemented with the Navier friction boundary conditions, in a general (curved) domain in $\mathbb{R}^3$ when the viscosity is small. By constructing a corrector, whose tangential components are exponentially decaying functions from the boundary, we prove the convergence, as the viscosity parameter tends to zero, of the Navier-Stokes solutions to the Euler solution in the norm of L^∞ in time and L^2 in space, as well as in that of L^2 in time and H^1 in space. This is a joint work with James P. Kelliher. (Received January 19, 2011)

1068-35-294 **Aynur Bulut*** (abulut@math.utexas.edu), 1 University Station C1200, Austin, TX 78712-0257. *Global well-posedness and scattering for the defocusing energy-supercritical cubic nonlinear wave equation.*

In this talk, we will discuss the defocusing cubic energy-supercritical nonlinear wave equation in high dimensions. In particular, we prove that under an a priori assumption in the critical homogeneous Sobolev space all solutions are global and scatter. (Received January 19, 2011)

1068-35-314 **Jason L Metcalfe*** (metcalfe@email.unc.edu), Department of Mathematics, University of North Carolina, Chapel Hill, NC 27599-3250. *Decay for wave equations on high dimensional Schwarzschild black hole backgrounds.*

This is joint work with Parul Laul and focuses on proving dispersive-type estimates for wave equations on high dimensional black hole backgrounds. Of particular interest are a class of localized energy estimates. The (1+3)-dimensional analog of these have played a major role in recent results, including a proof of the long conjectured Price's law. (Received January 20, 2011)

1068-35-317 **Francesco Di Plinio*** (fradipli@indiana.edu), Rawles Hall, 831 E 3rd St, Bloomington, IN 47405. *Time-dependent attractors for equations of mathematical physics.*

I will describe the framework of attractors in time-dependent spaces introduced in the article "Time-dependent attractor for the oscillon equation", joint work with Gregory S. Duane and Roger Temam, published on DCDS-A 29 (1), 2011. The oscillon equation, arising from a model of relativistic mechanics is a nonlinear wave equation with time-dependent (and possibly singular) speed of propagation. The explicit time-dependence of the phase space allows us to deal with the nonautonomous term acting at a functional level. I will compare our framework to the preexisting notions of uniform and pullback attractor, with particular emphasis on uniqueness questions and on the finite-dimensional reduction principle. (Received January 20, 2011)

1068-35-339 **Matthew D Blair*** (blair@math.unm.edu). *Strichartz estimates in polygonal domains.*

Strichartz inequalities are a family of space-time integrability estimates for the wave equation that rely on the dispersive effect of the solution map. They are of interest due to their applications to nonlinear equations. These estimates are reasonably well-understood when the equation is posed over Euclidean space. However, the

situation is more intricate when one starts to consider problems posed on polygonal domains. This is due to the fact that boundary conditions affect the flow of energy. Nonetheless, we will see that such inequalities are valid in this context. This is a joint work with G.A. Ford and J. Marzuola. (Received January 20, 2011)

1068-35-341 **Dong Li*** (dongli@math.ias.edu). *Recent development on Navier-Stokes equations.*
We will address some recent results on blowup of complex solutions of the 3D-Navier-Stokes system. (Received January 21, 2011)

1068-35-342 **Andrea R. Nahmod*** (nahmod@math.umass.edu), Department of Mathematics, University of Massachusetts Amherst, 710 N. Pleasant St., Amherst, MA 01003. *Almost sure GWP, Gibbs measures and gauge transformations.*
In this talk we will describe recent results establishing the invariance of the Gibbs measure associated to the periodic derivative NLS and the global well posedness of solutions to the Cauchy initial value problem with data living in its support. (Received January 21, 2011)

37 ► Dynamical systems and ergodic theory

1068-37-6 **Sodeif Ahadpour*** (sahadpour@yahoo.com), Mohaghegh Ardabili University, 1343137831 Ardabil, Ardabil, Iran, and **Yaser Sadra** (sadra@uma.ac.ir), Mohaghegh Ardabili University, 1356134331 Ardabil, Ardabil, Iran. *Topological properties of the binary visibility graph.*
By means of a binary visibility graph, we present a novel method to study random binary sequences. The behavior of the some topological properties of the binary visibility graph, such as the degree distribution, the clustering coefficient, and the mean path length have been investigated. Several examples are then provided to show that the numerical simulations confirm the accuracy of the theorems for finite random binary sequences. Finally, in this paper we propose, for the first time, three topological properties of the binary visibility graph as a randomness criteria (Received April 29, 2010)

1068-37-147 **Erin PJ Pearse*** (ep@ou.edu), Dept of Mathematics, Norman, OK 73019-0315. *Self-similar fractals as boundaries of networks.* Preliminary report.
Suppose F is a pcf self-similar fractal defined by an iterated function system. These contraction mappings can be used to construct a network N_F (connected weighted graph) which has F as a boundary (in a sense to be made precise). I will give the construction and discuss implications for the (reversible) random walk on N_F and the Laplacian on F. (Received January 17, 2011)

1068-37-163 **Michel L. Lapidus** (lapidus@math.ucr.edu), 900 Big Springs Rd., Surge Building, Department of Mathematics, Riverside, CA 92521, and **Robert G. Niemeyer*** (niemeyer@math.ucr.edu), 900 Big Springs Rd., Surge Building, Department of Mathematics, Riverside, CA 92521. *Consequences of tiling a prefractal flat surface.*
Let R be a polygon with interior angles measuring as rational multiples of π. The compact set $\Omega(R)$ with boundary R is a called a *rational billiard*. Associated with $\Omega(R)$ is what is called a *flat surface* $\mathcal{S}(R)$. The prefractal approximation KS_n of the Koch snowflake fractal KS is a rational polygon and $\Omega(KS_n)$ is a rational billiard. Associated with this prefractal billiard is a prefractal flat surface $\mathcal{S}(KS_n)$.

Despite the fact that KS is a nondifferentiable curve (and, hence, each point of KS lacks a well-defined tangent), we describe a particular family of periodic orbits of $\Omega(KS)$. We then examine the corresponding closed geodesics on their associated prefractal flat surfaces. Finally, we state a variety of conjectures on the existence of a true fractal billiard and an associated "*fractal flat surface*" (Received January 19, 2011)

1068-37-274 **Eva Curry*** (eva.curry@acadiau.ca), Department of Mathematics and Statistics, Acadia University, 12 University Ave., Wolfville, NS B4P 2R6, Canada. *A One-Step Test for Connectedness of Radix IFS Tiles.*
We present a sufficient condition for connectedness of self-affine tiles arising from a multidimensional radix representation (also known as a multidimensional number system), valid for all dimensions. (Received January 19, 2011)

41 ► Approximations and expansions

1068-41-20 **Xiaoping Shen*** (shenx@ohio.edu), Athens, OH 45701. *Digital signal representation with Slepian series.* Preliminary report.

The theoretical aspects of prolate spheroidal wave functions(Slepian functions) as the solution of energy concentration problem have been known for over forty years. In this talk, we give a brief review of Slepian functions and then report the recent numerical results on the Slepian series expansion for digitized signals. (Received November 24, 2010)

1068-41-131 **C. Sinan Gunturk**, **Mark Lammers**, **Alex Powell**, **Rayan Saab*** (rayans@math.ubc.ca) and **Ozgur Yilmaz**. *Sobolev Duals of Random Frames and Sigma-Delta Quantization for Compressed Sensing.*

Compressed sensing, as a signal acquisition method, has been shown to be highly effective for dimensionality reduction. On the other hand, quantization of compressed sensing measurements has been relatively underaddressed. In particular, the results of Candes, Romberg and Tao, and of Donoho guarantee that if a uniform quantizer of step size δ is used to quantize m measurements $y = \Phi x$ of a k-sparse signal $x \in \mathbb{R}^N$, where Φ satisfies the restricted isometry property, then the reconstruction error via ℓ_1-minimization is $O(\delta)$. This is the simplest and most commonly assumed approach for quantization of compressed sensing measurements.

We show that if instead of uniform quantization, an rth order $\Sigma\Delta$ quantization scheme with the same output alphabet is used to quantize y, then there is an alternative recovery method via Sobolev dual frames which guarantees a reduction of the approximation error by a factor of $(m/k)^{(r-1/2)\alpha}$ for any $0 \leq \alpha \leq 1$, if $m \gtrsim_r k(\log N)^{1/(1-\alpha)}$. The result holds with high probability on the initial draw of the measurement matrix Φ from the Gaussian distribution, uniformly for all k-sparse signals x satisfying a mild size condition on their supports. (Received January 16, 2011)

1068-41-143 **Palle Jorgensen**, **Keri Kornelson** and **Karen Shuman*** (shumank@math.grinnell.edu), Noyce Science Center, Grinnell College, Grinnell, IA 50112. *Iterated function systems and moment matrices: differences between the affine and non-affine cases.*

In this talk, we will consider extensions of the 2006 work of Escribano, Sastre, and Torrano on moments associated with affine iterated function systems. In particular, we will study some of the differences which arise between affine iterated function systems, which are well-understood in this context, and iterated function systems arising from measurable maps on $\mathbb{R}$ or $\mathbb{C}$. (Received January 17, 2011)

1068-41-281 **'Kale Oyedeji*** (koyedeji@morehouse.edu), Department of Physics, 830 Westview Dr., SW, Atlanta, GA 30314-3773, and **Ronald E. Mickens** (rmickens@cau.edu), Department of Physics, 237 Brawley Dr., SW, 30314 Atlanta, GA, Gabon. *Preliminary Results on the Solutions of* $\ddot{x} + x^3 = -2\epsilon\dot{x}^3$. Preliminary report.

We study the properties of a so-called "truly" nonlinear oscillator differential equation subject to initial conditions $x(0) = A$, $\dot{x}(0) = 0$. Using an energy method, we show that all solutions decrease to zero as $\epsilon \to \infty$. Next, a method of averaging is applied and an explicit approximation is calculated for the damped, oscillatory solutions. Finally, a finite difference scheme is constructed and then used to determine numerical solutions to our nonlinear differential equation. We find that there is good qualitative agreement between the numerical and analytical approximate solutions. (Received January 19, 2011)

42 ► Fourier analysis

1068-42-19 **Dorin Ervin Dutkay*** (ddutkay@gmail.com). *Fourier bases on fractals.*

We present some recent results on orthonormal bases and frames of exponentials on fractal measures. We show how spectral properties of these bases are related to geometric properties of the measure. (Received November 23, 2010)

1068-42-22 **Michael T Lacey*** (lacey@math.gatech.edu), math, Georgia Tech, Atlanta, GA 30332. *Recent Results on Two Weight Inequalities for Singular Integrals.* Preliminary report.

The two weight problem for a given singular integral operator T asks for a characterization, if possible, for the norm inequality $\|T(f\sigma)\|_{L^p(w)} \leq C\|f\|_{L^p(\sigma)}$. Here, w, σ are two non-negative Borel measures. While a solution of this is not even known for the Hilbert transform, and for $p = 2$, there are results known that hold for rather degenerate pairs of measures. And these results have contributed to our understanding of these estimates of

singular integral operators acting on $L^p(w)$, with $w \in A_p$. We will survey recent results on this topic. (Received December 08, 2010)

1068-42-23 **Alex Iosevich*** (iosevich@math.rochester.edu), 145 Dunrovin Lane, Rochester, NY 14618, and **Krystal Taylor**, University of Rochester, Rochester, NY 14618. *Distribution of lattice points in families of domains in Euclidean space.*

We shall consider variable coefficient families of dilated domains in Euclidean space and study the problem of distribution of lattice points inside these domains and their boundaries. Sobolev bounds for generalized Radon transforms play a critical role. (Received December 08, 2010)

1068-42-25 **J. Marshall Ash*** (mash@math.depaul.edu), DePaul University, Mathematics Department, Chicsgo, IL 60614. *A survey of multidimensional generalizations of Cantor's uniqueness theorem for trigonometric series.* Preliminary report.

Georg Cantor's pointwise uniqueness theorem for one dimensional trigonometric series says that if, for each x in $[0, 2\pi)$, $\sum c_n e^{inx} = 0$, then all $c_n = 0$. The meaning of the summation is $\lim_{N\to\infty}(c_0 + \sum_{n=1}^{N} t_n(x))$, where $t_n(x) = c_n e^{inx} + c_{-n}e^{-inx}$. In dimension d, $d \geq 2$, we begin by assuming that for each x in $[0, 2\pi)^d$, $\sum c_n e^{inx} = 0$ where $n = (n_1, \ldots, n_d)$ and $nx = n_1x_1 + \cdots + n_dx_d$. It is quite natural to group together all terms whose indices differ only by signs, just as was done by Cantor in the one dimensional case. This removed all ambiguity in the one dimensional case. But here there are still several different natural interpretations of the infinite multiple sum, and, correspondingly, several different potential generalizations of Cantor's Theorem. For example, in two dimensions, two natural methods of convergence are circular convergence and square convergence. In the former case, the generalization is true, and this has been known since 1971. In the latter case, this is still an open question. In this historical survey, I will discuss these two cases as well as the cases of unrestricted rectangular convergence, iterated convergence, and restricted rectangular convergence. (Received December 15, 2010)

1068-42-46 **Qiyu Sun*** (qsun@mail.ucf.edu), Department of Mathematics, University of Central Florida, FL 32816. *Left-Inverses of Fractional Laplacian and Sparse Stochastic Processes.* Preliminary report.

The fractional Laplacian $(-\triangle)^{\gamma/2}$ commutes with the primary coordination transformations in the d-dimensional Euclidean space: dilation, translation and rotation, and has tight link to splines, fractals and stable Levy processes. For $0 < \gamma < d$, its inverse is the classical Riesz potential I_γ. In this talk, we extend the definition of the classical Riesz potential I_γ to any non-integer number γ larger than d and apply that extension to solve the stochastic partial differential equation $(-\triangle)^{\gamma/2}\Phi = w$ with white Poisson noise as its driving term w. (Received January 06, 2011)

1068-42-71 **Winston Ou*** (wcwou@scrippscollege.edu), 1030 Columbia Avenue, Claremont, CA 91711. *Irregularity of Distributions and Multiparameter A_p Weights.*

Roth and Schmidt's seminal result in distribution theory, giving lower bounds on the L^p norm of the "discrepancy function" (measuring, for a collection of points in the unit cube, the discrepancy between the actual and expected number of points in a rectangle with one corner at the origin), is shown via weighted multiparameter Littlewood-Paley theory to be extendable to the case where the measure is a product Muckenhoupt A_p weight. (Received January 12, 2011)

1068-42-73 **Fedor Nazarov**, Dept of Mathematics, University of Wisconsin, Madison, WI 53706, and **James Michael Wilson*** (wilson@cems.uvm.edu), 16 Colchester Avenue, Burlington, VT 05405. *The Buckley and the standard dyadic square functions.*

We discuss the relations between two natural forms of the dyadic square function on $\mathbf{R}^d$, denoted $S(f)$ ("standard") and $S_b(f)$ ("Buckley"). They are often confounded, but are only equal if $d = 1$. $S(f)$ dominates $S_b(f)$ but, if $d > 1$, $S_b(f)$ can be in L^∞ while $S(f) \equiv \infty$. Nevertheless, having $S_b(f) \in L^\infty$ implies that $S(f)$ is, in some sense, in the local exponential L^2 class. It is well-known that if $S(f) \in L^\infty$ then f is in the local exponential L^2 class, and this cannot be improved. We show that $S_b(f) \in L^\infty$ also implies that f is in the local exponential L^2 class. (Received January 12, 2011)

1068-42-106 **Ivan W. Selesnick*** (selesi@poly.edu), Polytechnic Institute of NYU, 6 Metrotech Center, Brooklyn, NY 11201. *The Decomposition of Signals into Resonance Components.*

Numerous signals arising from physiological and physical processes are not only non-stationary but also posses a mixture of sustained oscillations and non-oscillatory transients that are difficult to disentangle by linear methods. Examples of such signals include speech, biomedical and geophysical signals. This talk describes the decomposition of such signals into 'resonance' components: A high-resonance signal being comprised of sustained

oscillations; a low-resonance signal being comprised mostly of non-oscillatory transients of unspecified shape and duration. The signal decomposition approach presented in this talk utilizes sparse signal representations and recently developed tunable Q-factor wavelet transforms. (Received January 14, 2011)

1068-42-111 **Kangyu Ni**, **Somantika Datta*** (somantikad@gmail.com), **Prasun Mahanti**, **Svetlana Roudenko** and **Douglas Cochran**. *Deterministic compressed sensing for efficient image reconstruction.*

The application of compressed sensing techniques for image reconstruction using deterministic sensing matrices will be discussed. Specifically, the sensing matrices used are constructed by either discrete chirps or second-order Reed-Muller sequences. Previous works by Applebaum et al. and Howard et al. used chirps and Reed-Muller sequences, respectively, for very sparse one-dimensional signals and their experimental results are quite good. The speed and accuracy suffer when the degree of sparsity is not high, making it inapplicable for natural and medical images. We propose efficient reconstruction algorithms for images with deterministic compressed sensing. The steps of the reconstruction algorithms include: initial best approximation, a greedy algorithm for the nonzero locations, and a new approach in the least squares method. (Received January 15, 2011)

1068-42-112 **Steve M Hudson*** (hudsons@fiu.edu) and **Laura DeCarli**. *Minimal Support Estimates.* Preliminary report.

We show that solutions of certain differential equations cannot be supported on small sets. One result generalizes the well-known Faber-Krahn inequality to equations with variable coefficients. These results can also be interpreted as unique continuation results. (Received January 15, 2011)

1068-42-119 **Yen Do*** (yendo@math.gatech.edu), **Camil Muscalu** and **Christoph Thiele**. *Variational estimates for paraproducts.*

I will describe a new type of estimates for paraproducts and an application to time-frequency analysis. Joint work with Camil Muscalu and Christoph Thiele. (Received January 16, 2011)

1068-42-151 **Palle E.T. Jorgensen**, **Keri A. Kornelson*** (kkornelson@math.ou.edu) and **Karen L. Shuman**. *Families of orthonormal bases for fractal measures.* Preliminary report.

For certain scale parameters, it is known (Jorgensen, Pedersen 1998) that the equilibrium measure generated by an Bernoulli affine iterated function system is spectral, i.e. that the $L^2(\mu)$ Hilbert space contains an orthonormal basis of complex exponential functions. These ONBs are not generally unique. We produce families of ONBs for fixed scale values. These collections of ONBs naturally produce isometry operators on the Hilbert space which contain their own type of self-similarity. (Received January 17, 2011)

1068-42-156 **David Cruz-Uribe** and **Kabe Moen*** (moen@math.wustl.edu), Washington University, One Brookings Drive, Department of Mathematics, Box 1146, St. Louis, MO 63130. *Sharp two weight inequalities for commutators of singular integrals.*

We will discuss sufficient conditions on pairs of weights (u, v) for commutators of classical operators to be bounded from $L^p(v)$ to $L^p(u)$. Our results are sharp and they demonstrate that commutators are more singular than the underlying operator. This work is based on a collaboration with David Cruz-Uribe. (Received January 17, 2011)

1068-42-177 **Maria Carmen Reguera*** (mreguera@math.gatech.edu) and **Christoph Thiele**. *A counterexample to Muckenhoupt-Wheeden Conjecture.*

Muckenhoupt-Wheeden Conjecture asserts that given any weigth w, a Calderón-Zygmund operator T should map $L^1(Mw)$ to $L^{1,\infty}(w)$, where M is the Hardy-Littlewood maximal operator. When T is replaced by the maximal operator M, the inequality is known to be true and was proven by C. Fefferman and E. Stein in early seventies. We construct a weight w for which the Hilbert transform fails to map $L^1(Mw)$ to $L^{1,\infty}(w)$, hence disproving the Conjecture. The proof is a simplification of a previous construction for the dyadic case by the author. This is joint work with Christoph Thiele. (Received January 18, 2011)

1068-42-204 **Carlos Peréz** (carlosperez@us.es) and **Rodolfo H. Torres*** (torres@math.ku.edu). *A new geometric regularity condition for the end-point estimates of bilinear Calderón-Zygmund operators.* Preliminary report.

A new minimal regularity condition involving certain integrals of the kernels of bilinear Calderón-Zygmund operators over appropriate families of dyadic cubes is presented. This regularity condition warrants the existence of end-point estimates for such operators and is weaker than other typical regularity assumptions considered in the literature. (Received January 18, 2011)

1068-42-207 **A. Eduardo Gatto** and **Wilfredo O Urbina*** (wurbinaromero@roosevelt.edu), 430 S Michigan Ave, Chicago, IL 60626. *Boundedness of Riesz and Bessel fractional derivatives of order bigger than one, on Gaussian Lipschitz spaces.*

Let $\beta > 0$, D^γ_β the Riesz Fractional Derivative of order β is defined by

$$D^\gamma_\beta f = \frac{1}{c^k_\beta} \int_0^\infty t^{-\beta-1}(P_t - I)^k \, f dt,$$

and $\mathcal{D}^\gamma_\beta$, the Bessel Fractional Derivative of order β is defined by

$$\mathcal{D}^\gamma_\beta f = \frac{1}{c^k_\beta} \int_0^\infty t^{-\beta-1}(e^{-t}P_t - I)^k \, f dt,$$

where $c^k_\beta = \displaystyle\int_0^\infty u^{-\beta-1}(e^{-u}-1)^k du < \infty$, since $\beta > 0$ and k is the smallest integer greater than β.

For $\alpha \geq 0$, let n be the smallest integer greater than α, the *Gaussian Lipschitz* space $Lip_\alpha(\gamma)$ is the set of functions $f \in L^\infty(\gamma)$ such that

$$\|\frac{\partial^n P_t f}{\partial t^n}\|_\infty \leq A_\alpha(f)\, t^{-n+\alpha}. \tag{1}$$

In this talk we will prove the following results: Let $1 < \beta < \alpha$ then

i) D^γ_β is bounded from $Lip_\alpha(\gamma)$ into $Lip_{\alpha-\beta}(\gamma)$

ii) $\mathcal{D}^\gamma_\beta$ is bounded from $Lip_\alpha(\gamma)$ into $Lip_{\alpha-\beta}(\gamma)$

(Received January 18, 2011)

1068-42-209 **A Eduardo Gatto** and **Ebner A Pineda*** (ebner.pineda@gmail.com), Residencias Oriente, Edificio Bolivar, Apartamento 8-4, Avenida Pedro Leon Torres, Barquisimeto, 3001, Venezuela, and **Wilfredo O Urbina**. *Riesz and Bessel Fractional Derivatives on function spaces for the Gaussian Measure.* Preliminary report.

Let $0 < \beta < 1$, the Riesz Fractional Derivative of order β, is defined by

$$D^\gamma_\beta f = \frac{1}{c_\beta} \int_0^\infty t^{-\beta-1}(P_t - I)\, f dt,$$

and the Bessel Fractional Derivative by

$$\mathcal{D}^\gamma_\beta f = \frac{1}{c_\beta} \int_0^\infty t^{-\beta-1}(e^{-t}P_t - I)\, f dt,$$

where $c_\beta = \displaystyle\int_0^\infty u^{-\beta-1}(e^{-u}-1)du < \infty$, since $0 < \beta < 1$.

For $\alpha \geq 0$, let k be the smallest integer greater than α and $1 \leq p, q < \infty$, the Gaussian Besov-Lipschitz space $B^\alpha_{p,q}(\gamma_d)$ is the set of functions $f \in L^p(\gamma_d)$ for which

$$\left(\int_0^\infty \left(t^{k-\alpha}\left\|\frac{\partial^k}{\partial t^k}P_t f\right\|_{p,\gamma_d}\right)^q \frac{dt}{t}\right)^{1/q} < \infty. \tag{1}$$

and the Gaussian Triebel-Lizorkin space $F^\alpha_{p,q}(\gamma_d)$ is defined analogously. In this talk, we will prove the next results:

Let $1 \leq p, q < +\infty$, $0 < \beta < \alpha < 1$ then D^γ_β and $\mathcal{D}^\gamma_\beta$ are bounded from $B^\alpha_{p,q}(\gamma_d)$ into $B^{\alpha-\beta}_{p,q}(\gamma_d)$ and also from $F^\alpha_{p,q}(\gamma_d)$ into $F^{\alpha-\beta}_{p,q}(\gamma_d)$. (Received January 18, 2011)

1068-42-214 **Michael Goldberg*** (goldbeml@ucmail.uc.edu), University of Cincinnati, Department of Mathematical Sciences, 839 Old Chem Hall, Cincinnati, OH 45221-0025. *Dispersive Estimates in $\mathbf{R}^3$ with Surface-Measure and Lower Dimensional Potentials.*

We prove a dispersive estimate for the linear Schrödinger evolution associated to the operator $H = -\Delta + \mu$, where μ is a compactly supported signed measure in $\mathbf{R}^3$ with dimension greater then 3/2. In particular this class includes potentials formed as the product of a bounded function $v(x)$ times the surface measure of a 2-dimensional compact surface $\Sigma \subset \mathbf{R}^3$. The key step makes use of a Fourier restriction estimate due to Burak Erdogan. An extension to unbounded functions $v(x)$ satisfying a local Kato condition follows from arguments developed in collaboration with Marius Beceanu. (Received January 18, 2011)

1068-42-292 **Vasily Vasyunin*** (vasyunin@pdmi.ras.ru). *General extremal problems for integral functionals on BMO and their Bellman functions.*

There are a few classical BMO problems that have been solved by the Bellman function method (for instance, the integral and weak forms of the John–Nirenberg inequality and L^p-estimates of BMO functions). These results (mostly in collaboration with L. Slavin) have made clear that it is possible to formulate a rather general method of solving a big class of extremal problems for integral functionals on BMO. The work is still in progress, but I would like to describe some results in that direction. (Received January 19, 2011)

1068-42-313 **Leonid Slavin*** (leonid.slavin@uc.edu) and **Winston Ou**. *The sharp $A^\infty \to A_1$ action of the dyadic maximal operator via Bellman functions.*

We construct the upper and lower Bellman functions for the A_1 characteristic of the dyadic maximal function of an A^∞ weight w. The resulting estimates are sharp with respect to $[w]_{A_\infty}$. The proofs, dependent in part on solving a Monge–Ampère equation on a plane domain, are complicated by the fact that the domain is non-convex. This is joint work with Winston Ou. (Received January 20, 2011)

1068-42-315 **David Jimenez** (djimenez@math.uh.edu), Department of Mathematics, University of Houston, 651, Phillip G. Hoffam Hall, Houston, TX 77204-3008, and **Manos Papadakis*** (mpapadak@math.uh.edu), Department of Mathematics, University of Houston, 651, Phillip G. Hoffam Hall, Houston, TX 77204-3008. *The Effect of Filtering Directional Bias on Analog to Digital Conversion in Multidimensions.* Preliminary report.

Digital filters for 2D or 3D-images are generated as the Fourier transforms of square-integrable $\mathbb{Z}^d$-periodic functions ($d = 2, 3$). Depending on the variability of the decay rate of the filter's Fourier transform, which we call directional bias of the filter, the reconstruction errors of the input image, say f, may vary. This variation also depends on the rotations of the input image. More specifically, we study the effects on the truncation error $E_N(f) = inf_I\{||f - \sigma_I(f)|| : \ I \subset \mathbb{Z}^d, \ |I| \leq N\}$ of the directional distribution of the decay of $\hat{\psi}$ and $\hat{\phi}$, where $\sigma_I(f)(x) = \sum_{n\in I} < f, \psi(\cdot - n) > \phi(x - n)$, ϕ is the reconstruction kernel and ψ is the analysis kernel.

We demonstrate the effect of the directional distribution of the decays of the analysis and synthesis kernels on the construction of artifact-free synthetic dendritic arbors used as phantoms for the benchmarking the accuracy of neuroscience imaging software. These synthetic data are part of joint work with P.H. Herrera and I.A. Kakadiaris. (Received January 20, 2011)

1068-42-325 **Alex Iosevich*** (iosevich@math.rochester.edu), 145 Dunrovin Lane, Rochester, NY 14618, and **Krystal Taylor** (taylor@math.rochester.edu), 78 Whiteford Road, Rochester, NY 14620. *Geometric consequences of Fourier analytic operator bounds.*

We shall discuss some examples of applications of Fourier analytic operator bounds to problems in geometric measure theory and combinatorics. (Received January 20, 2011)

1068-42-333 **Eric T Sawyer*** (sawyer@mcmaster.ca), Department of Mathematics and Statistics, McMaster University, 1280 Main St. W., Hamiton,, Ontario L8s 4K1, Canada. *Weighted norm inequalities.* Preliminary report.

We report on recent work related to weighted inequalities for singular integrals. (Received January 20, 2011)

43 ► Abstract harmonic analysis

1068-43-15 **Inmi Kim*** (inmikim2@illinois.edu), University of Illinois at Urbana-Champaign, Department of Mathematics, 1409 W. Green St., Urbana, IL 61801. Gabor Frames with Trigonometric Spline Dual Windows*, in preparation.*

Abstract. A Gabor system is a collection of modulated and translated copies of a window function. A function in L^2 can be analyzed and then synthesized (reconstructed) with two different Gabor systems generated by a window g and a dual window h. This paper constructs explicit examples of Gabor dual windows having trigonometric form. The windows have fixed support and have an arbitrary smoothness. Further, we derive a sufficient condition on the norm of the modulation lattice to have explicit dual Gabor windows for every dimension. In the discrete time domain, our trigonometric form windows would allow us to evaluate the Gabor coefficients efficiently using the Discrete Fourier Transform. (Received November 11, 2010)

1068-43-28 **Susanna Dann*** (sdann@math.lsu.edu) and **Gestur Olafsson**. *Paley-Wiener Theorems on $\mathbb{R}^n$ as a Gelfand Pair.*

One of the important questions related to any integral transform on a manifold $\mathcal{M}$ or on a homogeneous space G/K is the description of the image of a given space of functions. If $\mathcal{M} = G/K$, where (G, K) is a Gelfand pair, then the harmonic analysis is closely related to the representations of G and the direct integral decomposition of $L^2(\mathcal{M})$ into irreducible representations of G. $\mathbb{R}^n$ can be realized as the quotient $\mathbb{R}^n \simeq G/\mathrm{SO}(n)$, where G is the orientation preserving Euclidean motion group $\mathbb{R}^n \rtimes \mathrm{SO}(n)$. The pair $(G, \mathrm{SO}(n))$ is a Gelfand pair. Hence this realization of $\mathbb{R}^n$ comes with its own natural Fourier transform derived from the representation theory of G. The representations of G that are in the support of the Plancherel measure for $L^2(\mathbb{R}^n)$ are parameterized by $\mathbb{R}^+$. After recalling the Fourier transform on Gelfand pairs, we describe the image of smooth compactly supported

functions under the Fourier transform with respect to the spectral parameter. Then we discuss projective limits of these spaces. (Received January 19, 2011)

1068-43-109 **Gestur Olafsson*** (olafsson@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, and **Jens Christensen** and **Azita Mayeli**. *Sampling in spaces of bandlimited functions on commutative spaces.*

Let G be a Lie group and K a compact subgroup. The space $X = G/K$ is *commutative* if the Banach algebra $L^1(X)^K$, of K-invariant integrable function on X, is commutative. We give an overview of basic harmonic analysis on those spaces. We introduce the notation of bandlimited functions and then give a sampling theorem for those spaces. (Received January 15, 2011)

1068-43-237 **Oleksandra V Beznosova*** (alexbeznosova@yahoo.com) and **Alexander Reznikov**. *The limiting case of the Reverse Holder inequalities and the A_∞ condition.* Preliminary report.

As $p \to 1$, p - Reverse Holder inequalities for a weight w degenerate to a reverse Jensen's inequality of the $L \log L$-type. We show that the constant in this inequality depends on the A_∞ constant of the weight w at most linearly. (Received January 19, 2011)

44 ► Integral transforms, operational calculus

1068-44-57 **Alexander Katsevich*** (akatsevi@mail.ucf.edu), Mathematics Dept, Orlando, FL 32816. *Singular value decomposition for the truncated Hilbert transform.*

Starting from a breakthrough result by Gelfand and Graev, inversion of the Hilbert transform became a very important tool for image reconstruction in tomography. In particular, their result is useful when the tomographic data are truncated and one deals with an interior problem. As was established recently, interior problem admits a stable and unique solution when some a priori information about the object being scanned is available. The most common approach to solving the interior problem is based on converting it to the Hilbert transform and performing analytic continuation. Depending on what type of tomographic data are available, one gets different Hilbert inversion problems. In this talk we consider several such problems and establish singular value decomposition for the operators involved. We also propose algorithms for performing analytic continuation. (Received January 10, 2011)

45 ► Integral equations

1068-45-305 **Irina Mitrea*** (imitrea@ima.umn.edu), IMA, University of Minnesota, 207 Church St. S.E., Lind Hall, Minneapolis, MN 55455. *Boundary Value Problems for Higher Order Elliptic PDEs.*

In this talk I will present recent results dealing with the well-posedness of elliptic boundary value problems in non-smooth domains, and spectral properties of singular integral operators associated with such problems. (Received January 19, 2011)

46 ► Functional analysis

1068-46-48 **Tadeusz Iwaniec**, **Leonid V. Kovalev*** (lvkovale@syr.edu) and **Jani Onninen**. *Diffeomorphic approximation of Sobolev homeomorphisms.*

Every homeomorphism $h\colon \mathbb{X} \to \mathbb{Y}$ between planar open sets that belongs to the Sobolev class $W^{1,p}(\mathbb{X}, \mathbb{Y})$, $1 < p < \infty$, can be approximated in the Sobolev norm by diffeomorphisms. (Received January 06, 2011)

1068-46-117 **Hafedh Herichi*** (herichi@math.ucr.edu), Department of Mathematics, University of California, Riverside, 900 University Ave, Riverside, CA 92521, and **Michel. L. Lapidus** (lapidus@math.ucr.edu), Department of Mathematics, University of California, Riverside, 900 University Ave, Riverside, CA 92521. *On the spectral operator and the convergence of its Euler product in the critical strip.*

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. The spectral operator is defined on a suitable Hilbert space as the operator mapping the counting function of a generalized fractal string to the counting function of its associated spectral measure,

$$a(f)(t) = \zeta(\partial)(f)(t) = \prod_{p \in \mathbf{P}} (1 - p^{-\partial})^{-1}(f)(t),$$

where f is the counting function of the generalized fractal string, ζ is the Riemann zeta function and $\mathbf{P}$ is the set of prime numbers. It relates the spectrum of a fractal string with its geometry. The spectral operator also has an Euler product representation, which provides a counterpart to the usual Euler product expansion for the Riemann zeta function, but is convergent in the critical strip of the complex plane. During this talk, we will be discussing some fundamental properties of this operator and present conditions ensuring convergence of its Euler product. (Received January 17, 2011)

1068-46-165 **Youssef Naim Raffoul*** (youssef.raffoul@notes.udayton.edu), Dayton, OH 45469-2316, **Eric Kaufmann**, Little Rock, AR 72204, and **Nick Kosmatov**, Little Rock, AR 72204. *Positive Periodic Solutions In Neutral Dynamic Equations on a Time Scale.*

Let $\mathbb{T}$ be a periodic time scale. We use a fixed point theorem due to Krasnosel'skiĭ to show that the nonlinear neutral dynamic system

$$x^{\Delta}(t) = -a(t)x^{\sigma}(t) + c(t)x^{\tilde{\Delta}}(\tau(t)) + q\left(t, x(\tau(t))\right),\ t \in \mathbb{T},$$

with delay $\tau(t)$ has a positive periodic solution. Here x^{Δ} is the Δ-derivative on $\mathbb{T}$ and $x^{\tilde{\Delta}}$ is the Δ-derivative on $\tau(\mathbb{T})$.
(Received January 17, 2011)

49 ► Calculus of variations and optimal control; optimization

1068-49-14 **Paul L. Goethals*** (pgoetha@clemson.edu), Department of Industrial Engineering, 150 Freeman Hall, Clemson, SC 29634, and **Byung Rae Cho**. *Process and Product Optimization: Developing a Road Map to the Most Profitable System Settings.*

In manufacturing, when product characteristics fail to achieve their desired target value or are incapable of meeting their designed specifications, there are frequently some processing costs involved with the outcome. The magnitude of the processing cost may vary widely for the manufacturer, depending on whether the non-conforming characteristic requires additional work or must be discarded altogether. The customer may also experience the cost of a loss in product quality when a characteristic is incapable of achieving its intended value. Given this tradeoff of costs, the identification of the optimal process mean for a characteristic is frequently an objective; it can often translate to significant monetary gain for the manufacturer. In this research, a reverse optimization scheme is proposed that relates the location of the optimal process mean for a characteristic to an experimental factor space. By doing so, one is able to identify the system settings for a product that support minimizing the overall processing cost. A comparison of several algorithms is provided to suggest the most appropriate technique in arriving at solutions. (Received November 11, 2010)

1068-49-60 **Thomas Yang*** (yang482@erau.edu). *New Techniques for Hidden Source Signal Recovery in Highly Dynamic Environments.*

Independent Component Analysis (ICA) is a powerful statistics analysis tool capable of revealing hidden mechanisms and source signals from their combinations. It has a wide variety of practical applications in areas like image and speech processing, telecommunications, financial engineering, and biomedical signal processing, etc. The major advantage of ICA is that little knowledge is required about the mixing process of the source signals. In this talk, we will introduce a family of ICA algorithms we recently developed for highly dynamic environments, i.e., the source signals' mixing process is varying with time rapidly. For example, in mobile cellular communication applications, the user may be constantly moving, and/or may experience "handover" between two service towers. The key to source separation in this scenario is to assure fast convergence of the algorithms. Our algorithms work for both real and complex valued signals with superior convergence properties. (Received January 10, 2011)

1068-49-122 **Xiaojing Ye*** (xye@ufl.edu), Department of Mathematics, 358 Little Hall, University of Florida, Gainesville, FL 32611, and **Yunmei Chen** (yun@ufl.edu), Department of Mathematics, 358 Little Hall, University of Florida, Gainesville, FL 32611. *Total Variation Based Image Reconstruction in Partially Parallel Imaging.*

In this talk, I will present our recent developments in fast algorithms for total variation-based image reconstruction in partially parallel magnetic resonance imaging (PPI) where the inversion matrix is large and illconditioned. These algorithms utilize variable splitting technique to decouple the original problem into more easily solved subproblems. The first algorithm adopts the recently developed split Bregman algorithm to deal with the constraint arising from variable spliting, and applies the Barzilai-Borwein step size optimization method to significantly improve the convergence rate. The second algorithm exploits the special structure of the PPI reconstruction problem by decomposing it into one subproblem involving Fourier transforms and another subproblem that can be treated by primal-dual hybrid gradient (PDHG) scheme. Numerical results and comparisons with recently developed methods indicate the efficiency of the proposed algorithms. (Received January 16, 2011)

1068-49-124 **Florian A Potra*** (potra@umbc.edu), Department of Mathematics and Statistics, 1000 Hilltop Circle, Baltimore, MD 21250. *Interior point methods in wide neighborhoods of the central path.*

Until recently, the best complexity results for linear programming, quadratic programming and monotone linear complementarity problems were obtained by interior point methods acting in a small neighborhood of the central path, while the best practical performance was obtained by algorithms acting in wide neighborhoods. The gap between theory and practice was due both to the fact that algorithms based on small neighborhoods tend to perform more consistently, and to the fact that interior point methods acting in large neighborhoods are more difficult to analyze. The talk presents an overview of recent theoretical results that have closed this gap, and proposes new path following algorithms that act in a wide neighborhood of the central path and have optimal computational complexity. (Received January 16, 2011)

1068-49-141 **Jiyuan Tao***, 4501 North Charles Street, Baltimore, MD 21210. *The Jordan Quadratic Strict Semimonotonicity (JQSSM) and Related Properties in Euclidean Jordan Algebras.*

In this talk, we present the Jordan quadratic strict semimonotonicity (JQSSM) and related properties in Euclidean Jordan algebras V. Specifically, we talk about the ultra SSM-property for a linear transformation on V. We give a characterization for the Jordan quadratic SSM (JQSSM)-property on a simple Euclidean Jordan algebra. Also, we show that some interconnections between the strict semimonotonicity (SSM)-property, the Jordan linear SSM (JLSSM)-property, and the (JQSSM)-property on V. (Received January 17, 2011)

1068-49-174 **M. Seetharama Gowda*** (gowda@umbc.edu), 1000 Hilltop Circle, Baltimore, MD 21250. *On the equivalence of Q and P properties for Z-transformations on Euclidean Jordan algebras.*

In the setting of standard linear complementarity problems, for a Z-matrix (a matrix with non-positive off-diagonal entries), the solvability of all corresponding linear complementarity problems is equivalent to the P property (that is, all principal minors are positive). With appropriate generalizations, we study this equivalence in the context of symmetric cone linear complementarity problems. Motivated by results for Lyapunov and Stein transformations on the space of all real n by n symmetric matrices (with relevance to dynamical systems), we describe such an equivalence for Lyapunov-like transformations and provide a partial result for Z-transformations. (Received January 18, 2011)

1068-49-195 **Ming-Jun Lai** (mjlai@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602, and **Jingyue Wang*** (jwang@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602. *An Unconstrained ℓ_q Minimization with $0 < q \leq 1$ for Sparse Solution of Under-determined Linear Systems.*

We study an unconstrained version of the ℓ_q minimization for the sparse solution of under-determined linear systems for $0 < q \leq 1$. Although the minimization is nonconvex when $q < 1$, we introduce a regularization and develop an iterative algorithm. We show that the iterative algorithm converges and the iterative solutions converge to the sparse solution under some additional assumptions on under-determined linear systems. Numerical experiments are presented to demonstrate the effectiveness of our approach. (Received January 18, 2011)

1068-49-243 **Cosmin G Petra*** (petra@mcs.anl.gov) and **Mihai Anitescu**. *Scalable Stochastic Programming via Interior-point Methods.*

We present our recent efforts in solving large scale stochastic programming problems on massively parallel machines. The solution of sample average approximation problems is obtained using an interior-point framework

in which the scenarios are decomposed using a Schur-complement technique and distributed across nodes. We introduce a stochastic preconditioner for the Schur complement that removes the expensive factorization of the dense Schur complement from the parallel execution flow. A considerable increase in scalability is obtained for a wide range of cores. We also present the spectral analysis of the preconditioned matrix which indicates an exponential clustering of the eigenvalues of the preconditioned matrix around 1.

The preconditioning technique however suffers from a memory bottleneck as does the classical Schur-complement. In the second part of the talk we present a novel approach for solving the dense Schur-complement systems in a distributed memory environment. This approach not only removes the memory bottleneck but also improves the scalability. Over 90% strong scaling efficiency was obtained for large scale stochastic unit commitment problems on up to 2048 cores. (Received January 19, 2011)

51 ► Geometry

1068-51-54 **Tomoo Matsumura*** (matsumura@math.cornell.edu), 310 Malott Hall, Mathematics Department, Ithaca, NY 14853, and **Tara Holm**. *Equivariant cohomology for Hamiltonian torus actions on symplectic orbifolds.*

We start with the definition of Hamiltonian R-actions on symplectic orbifolds $[M/\mathsf{S}]$, where R and S are tori. We show an injectivity theorem and generalize Tolman-Weitsman's proof of the GKM theorem in this setting. The main example is the symplectic reduction $X//\mathsf{S}$ of a Hamiltonian T-manifold X by a subtorus S of T. This includes the class of symplectic toric orbifolds which are classified by labeled polytopes by Lerman-Tolman. We apply our method to show that the equivariant cohomology ring of a symplectic toric orbifold is isomorphic over $\mathbf{Z}$ to the Stanley-Reisner ring of the associated polytope. Furthermore, we define the equivariant Chen-Ruan cohomology ring and use the above results to establish a combinatorial method of computing this equivariant Chen-Ruan cohomology in terms of orbifold fixed point data. (Received January 09, 2011)

1068-51-75 **Shisen Luo*** (ssluo@math.cornell.edu). *Cohomology rings of good contact toric manifolds.*

A good contact toric manifold M is determined by its moment cone C. We compute the equivariant cohomology ring with $\mathbb{Z}$ coefficient of M in terms of the combinatorial data of C. Then under a smoothness criterion on the cone C, we compute the singular cohomology ring with $\mathbb{Z}$ coefficient of M in terms of the combinatorial data of C. (Received January 12, 2011)

1068-51-180 **Tullia Dymarz** and **Irine Peng*** (ipeng@indiana.edu), 831 E. 3rd Street, Bloomington, IN 47405. *Bilipschitz maps of boundaries of certain negatively curved homogeneous spaces.*

Let ∂M be the boundary minus a point of a negatively curved space of the form $\mathbb{R} \ltimes_M \mathbb{R}^n$ with the eigenvalues of M outside of the unit circle. In joint work with Dymarz, we show that a compactly acting uniform subgroup of quasi-similarities of ∂M can be conjugated into the subgroup of almost similarities. This extends earlier work of Dymarz and implies quasi-isometric rigidities of certain solvable Lie groups. (Received January 18, 2011)

1068-51-192 **Lev Buhovsky*** (levbuh@gmail.com) and **Yaron Ostrover**. *On the uniqueness of Hofer's geometry.*

In this talk we address the question whether Hofer's metric is unique among the Finsler-type bi-invariant metrics on the group of Hamiltonian diffeomorphisms. (Received January 18, 2011)

1068-51-228 **Rebecca Goldin*** (rgoldin@math.gmu.edu), MS 3F2, Department of Mathematical Sciences, George Mason University, 4400 University Drive, Fairfax, VA 22030, and **Susan Tolman**. *Canonical classes and Schubert calculus in the symplectic category.*

A longstanding question in algebraic geometry and combinatorics is how to describe (combinatorially) the intersections of Schubert varieties in the flag manifold. Algebraically, this is equivalent to finding a formula for the multiplicative coefficients of a natural basis on the cohomology ring of G/P. These "structure constants" are positive for geometric reasons, and their analogs in equivariant K-theory and equivariant cohomology also satisfy a generalized notion of positivity. For equivariant theories, there is also a notion of positivity given by the restriction of the cohomology classes to fixed points of a maximal torus action on the flag variety. This also has been shown to be positive. In this talk, I will describe what happens outside the algebraic category. This is joint work with Susan Tolman, University of IL, Champaign-Urbana. (Received January 18, 2011)

1068-51-318 **Praphat Xavier Fernandes*** (pxferna@emory.edu), Dept. of Math and CS, Emory Univ., 400 Dowman Dr., W401, Atlanta, GA 30322. *Quasi-Isometric Properties of Graph Braid Groups.*

We study the properties of flats in 2-dimensional graph braid groups and use this to exhibit an infinite collection of quasi-isometrically distinct graph braid groups. (Received January 20, 2011)

1068-51-321 **Irine Peng***, 831 E. 3rd Street, Bloomington, IN 47405. *Quasi-isometric rigidities of nilpotent-by-cyclic groups.*

Following the work of Farb and Mosher, who gave a complete quasi-isometric classifications of finitely presented, non-polycyclic abelian-by-cyclic groups, we show a similar rigidity phenomenon holds for a class of irreducible nilpotent-by-cyclic groups. (Received January 20, 2011)

52 ► Convex and discrete geometry

1068-52-134 **Chun-Kit Lai*** (cklai@math.cuhk.edu.hk), Department of Mathematics, The Chinese University of Hong Kong, Hong Kong, and **Ka-Sing Lau** and **Hui Rao**. *On structure of digit sets of self-similar tiles on* $\mathbb{R}^1$.

We study the structure of the digit sets $\mathcal{D}$ for the integral self-similar tiles $T(b, \mathcal{D})$. By investigating the the zeros of mask polynomial of $\mathcal{D}$ on the unit circle, we characterize the tile digit sets through some product of cyclotomic polynomials via a graph representation. We then show that all tile digit sets in any dimension are indeed integer tiles. Using this relationship, we explicitly classify the tile digit sets for $b = p^\alpha q$ in terms of the higher order modulo product-forms, which generalize previously known cases in literature. (Received January 16, 2011)

1068-52-138 **Wei-Zhao Guo** and **Tai-Man Tang*** (tmtang@xtu.edu.cn), School of Mathematics and Computational, Sciences, Xiangtan University, Xiangtan, Hunan 411105, Peoples Rep of China. *Topology of Planar Self-Affine Tiles with Consecutive Collinear Digit Sets of Low Complexity.*

In a planar tiling by a self-affine tile with consecutive collinear digit set, the neighbors of a tile are in layers. We say that such a tile is of low complexity if it has only a few layers of neighbors. While the structure of such tilings are understood, the topology of the tiles are not. A necessary and sufficient condition for them to be dislike is known. In general, non-disklike fractal tiles need not have holes, like the Heighway Dragon. In this talk, we show that a large class of non-disklike tiles in the title has nontrivial fundamental group. We reason with polygonal approximations of a tile from the outside. They have holes and this property is preserved in taking limit. (Received January 17, 2011)

1068-52-306 **Tyrrell B. McAllister*** (tmcallis@uwyo.edu), Ross Hall 202, Dept 3036, 1000 E. University Ave., Laramie, WY 82071-2000. *Non-integral analogues of reflexive polytopes.* Preliminary report.

An active area of research is to characterize the Ehrhart polynomials of convex integral polytopes. The dimension-2 case was solved by Scott in 1978 when he gave an inequality bounding the number of lattice points on the boundary of a convex integral polygon in terms of the number of lattice points in its interior. However, due to the phenomenon of quasi-period collapse, not all Ehrhart polynomials come from integral polytopes, even in dimension 2. Characterizing all Ehrhart polynomials of convex polygons remains open. We approach this problem by introducing and studying pseudo-reflexive polytopes, which are non-integral analogues of reflexive polytopes. (Received January 19, 2011)

53 ► Differential geometry

1068-53-68 **Ivan Losev*** (ivanlosev@math.mit.edu), 77 Massachusetts Avenue, Cambridge, MA 02139. *Classification of multiplicity free Hamiltonian actions of algebraic tori.*

We classify multiplicity free Hamiltonian actions of an algebraic torus on holomorphically symplectic Stein manifolds. Our classification should be thought as a complex analytic analog of Delzant's. (Received January 11, 2011)

1068-53-92 **Fernando Schwartz*** (fernando@math.utk.edu), Mathematics Department, University of Tennessee, 227 Ayres Hall, 1403 Circle Drive, Knoxville, TN 37996. *On how black holes contribute to the mass of the universe.*

I will describe the Penrose inequality of general relativity and sketch a proof of a version of it which partially solves a conjecture by Bray and Iga. (Received January 14, 2011)

1068-53-154 **Timothy E. Goldberg*** (timothy.goldberg@gmail.com), Lenoir-Rhyne University, Box 7141, Hickory, NC 28601. *Singular reduction of generalized complex manifolds.*

In 2006, Lin and Tolman developed an analogue of Hamiltonian reduction of symplectic manifolds for generalized complex manifolds. In this talk, we present a result in the direction of an analogue of Sjamaar and Lerman's singular reduction of Hamiltonian symplectic manifolds in the generalized complex context. Specifically, if a compact Lie group acts on a generalized complex manifold in a Hamiltonian fashion, then the partition of the global quotient by orbit types induces a partition of the Lin-Tolman quotient into generalized complex manifolds. We will discuss the setup and describe the proof of this theorem. (Received January 17, 2011)

1068-53-160 **John B. Etnyre*** (etnyre@math.gatech.edu), School of Mathematics, 686 Cherry Street, Georgia Institute of Technology, Atlanta, GA 30332, **Rafal Komendarczyk**, LA , and **Patrick Massot**, , France. *The Contact Sphere Theorem and Tightness in Contact Metric Manifolds.*

We establish an analog of the sphere theorem in the setting of contact geometry. Specifically, if a given three dimensional contact manifold admits a compatible Riemannian metric of positive 4/9-pinched curvature then the underlying contact structure is tight. The proof is a blend of topological and geometric techniques. A necessary technical result is a lower bound for the radius of a tight ball in a contact, not necessarily closed, 3-manifold. We will also discuss geometric conditions in dimension three for a contact structure to be universally tight in the nonpositive curvature setting. (Received January 17, 2011)

1068-53-176 **Ana Cannas da Silva**, **Victor Guillemin** and **Ana Rita Pires*** (arita@math.mit.edu). *Symplectic origami.*

An origami manifold is a manifold equipped with a closed 2-form which is symplectic everywhere except on a hypersurface, where it is a folded form whose kernel defines a circle fibration. In this talk, I will explain how an origami manifold can be unfolded into a collection of symplectic pieces and conversely, how a collection of symplectic pieces can be folded (modulo compatibility conditions), into an origami manifold. Using equivariant versions of these operations, we will see how classic symplectic results of convexity and classification of toric manifolds translate to the origami world. (Received January 18, 2011)

1068-53-218 **Rajan Amit Mehta** and **Xiang Tang*** (xtang@math.wustl.edu), Department of Mathematics, St. Louis, MO 63130. *From double Lie groupoids to local Lie 2-groupoids.* Preliminary report.

We apply the bar construction to the nerve of a double Lie groupoid to obtain a local Lie 2-groupoid. As an application, we recover Haefliger's fundamental groupoid from the fundamental double groupoid of a Lie groupoid. In the case of a symplectic double groupoid, we study the induced closed 2-form on the associated local Lie 2-groupoid, which leads us to propose a definition of a symplectic 2-groupoid. (Received January 18, 2011)

1068-53-235 **Daniel Halpern-Leistner*** (danielhl@math.berkeley.edu). *Morse theory for orbifolds and the Lefschetz hyperplane theorem.*

Orbifolds arise in the study of Marsden-Weinstein quotients and in the moduli problems of symplectic topology. Poincare' duality and other homological properties of manifolds continue to hold for orbifolds, but only for homology with rational coefficients. It is thus surprising that the Lefschetz hyperplane theorem, a classical theorem on the cohomology of compact Kaehler manifolds, continues to hold with integral coefficients if one uses "stacky" cohomology. I will discuss how the proof of this theorem requires us to extend Morse theory to orbifolds. Much of this story even works for more general differentiable stacks and Lie groupoids. (Received January 19, 2011)

1068-53-248 **Alvaro Pelayo*** (apelayo@math.wustl.edu), WA. *Symplectic and spectral theory of semitoric integrable Systems.*

we explain the classification of completely integrable Hamiltonian systems of semitoric type. (Received January 19, 2011)

1068-53-282 **Zuoqin Wang*** (wangzuoq@umich.edu), 530 Church Street, Ann Arbor, MI 48109.
Stability functions for Kaehler quotients with applications.

We are going to study the spectral properties of Kaehler manifolds in the context of Kaehler quantization. The main tool we are going to use is the "stability function", which roughly speaking is a function that compares quantum states before reduction with quantum states after reduction. We will also give some applications to toric geometry. This is a joint work with Victor Guillemin and Daniel Burns. (Received January 19, 2011)

1068-53-287 **Reyer Sjamaar*** (sjamaar@math.cornell.edu). *Lagrangian fibrations.* Preliminary report.

I will make some comments on action-angle variables, Lagrangian fibrations and isotropic realizations as studied by Duistermaat, Dazord and Delzant and others. (Received January 19, 2011)

1068-53-307 **François Ziegler*** (fziegler@georgiasouthern.edu), Department of Mathematical Sciences, Georgia Southern University, Statesboro, GA 30460-8093, and **Patrick Iglesias-Zemmour**, Hebrew University of Jerusalem. *Primary spaces.*

We call a Hamiltonian N-space *primary* if its equivariant momentum map is onto a single coadjoint orbit, U. In other words, such a space is as far as can be from multiplicity-free. When N is a Heisenberg group, Souriau's 'barycentric decomposition theorem' shows that all primary spaces are products of (coverings of) U with trivial N-spaces. For general N, the question whether such a factorization survives has long been open. In the present work we give 1) examples where factorization fails, and 2) a structure theorem extending Souriau's to general N. This provides the missing piece for a full 'Mackey theory' of Hamiltonian G-spaces, where G is an overgroup in which N is normal. (Received January 19, 2011)

1068-53-320 **Ken YK Chan*** (kyk2chan@math.uwaterloo.ca), Department of Pure Mathematics, University of Waterloo, 200 University Avenue West, Waterloo, Ontario N2L 3G1, Canada. *Floer theory of cleanly intersecting immersed Lagrangians.*

We investigate Floer theory of Lagrangians which are immersed with clean self-intersections. As a example, we will compute Lagrangian Floer cohomology for sphere and orientation covers of $\mathbb{RP}^n$ embedded as a Lagrangian submanifold of $\mathbb{CP}^n$. (Received January 20, 2011)

1068-53-336 **Renato Feres*** (feres@math.wustl.edu), Washington University, Campus Box 1146, Department of Mathematics, St. Louis, MO 63130. *Mechanics and probability.*

We consider a class of Markov chains derived from simple types of mechanical systems for which certain degrees of freedom must be viewed as random. We investigate the spectral theory of the associated transition probabilities operator as well as basic questions in the statistical physics of such systems. (Received January 21, 2011)

54 ► General topology

1068-54-7 **Ernie Manes*** (manes@mtdata.com), 321 Truce Road, Conway, MA 01341. *A topological interpretation of Börger's theorem.* Preliminary report.

A space is said to be **totally separated** if distinct points can be separated by clopen sets. Every space has a totally separated reflection. In 1987, Börger proved that a set functor T which preserves binary coproducts admits a unique ultrafilter-valued natural transformation which is a monad map if T is a monad. Let T be such a monad, and factor the induced monad map into its image $\rho : T \to H$ so that H is a coproduct preserving submonad of the ultrafilter monad. Each T-algebra is a topological space whose closed sets are its subalgebras. The following hold: (1) HX is Urysohn and extremally disconnected; (2) Every infinite closed subset of $H\omega$ contains a copy of $H\omega$; (3) ρ_X is the totally separated reflection of TX; (4) the H-algebras constitute the variety of T-algebras generated by $1+1$ and are a full subcategory of **Top**. When either T or H has countable rank, all compact metric spaces are H-algebras. (Received September 24, 2010)

1068-54-13 **T. R. Hamlett*** (ray.hamlett@oc.edu), Box 11000, 2501 E Memorial RD, Oklahoma City, OK 73136-1100. *On Weakly Lindelof and Almost Lindelof Spaces.* Preliminary report.

A space is said to be Almost Lindelof if every open cover has a countable subcollection whose closures cover, and is said to be Weakly Lindelof if every cover has a countable subcollection whose union is dense in the space. Basic results that are known are surveyed and some new results are given. (Received November 08, 2010)

1068-54-29 **Neil Hindman*** (nhindman@aol.com). *Some new results on the algebraic structure of βS.* Preliminary report.

Let S be an infinite discrete semigroup and let βS be its Stone-Čech compactification with the operation making βS a compact right topological semigroup with S contained in its topological center. Some kind of cancellation assumptions are needed for several results about left ideals and right ideals in βS. For example, $S^* = \beta S \setminus S$ is a left ideal of βS if and only if S is *weakly left cancellative* (meaning that for any $x, y \in S$, $\{z \in S : xz = y\}$ is finite). And "weakly right cancellative" is necessary, but not sufficient, for S^* to be a right ideal of βS.

In recent joint research with Lakeshia Legette and Dona Strauss, we established several results about the number of left and right ideals in βS that do not involve any cancellation assumptions. For example, we showed that if S does not contain a finite ideal, then there are at least $2^{\mathfrak{c}}$ minimal left ideals in βS. I will discuss this and similar recent results. (Received December 20, 2010)

1068-54-30 **Judith Roitman*** (roitman@math.ku.edu), Mathematics Department, University of Kansas, 1460 Jayhawk Blvd., Lawrence, KS 66049. *Paracompact box products, old and new.*

One of the classic cluster of unsolved problems in set theoretic topology relates to the paracompactness of countably many metrizable spaces. Results in the 1970's through 1990's generally involved consistency results; recently there have been real results about subspaces (due to the speaker) and, more recently, the weaker uniform box topology (due to Jocelyn Bell). This talk is a survey of these results. (Received December 21, 2010)

1068-54-36 **Jun Luo*** (luojun3@mail.sysu.edu.cn), School of Mathematics and Computational Sci., Sun Yat-Sen University, 135 West Xingang Street, GUANGZHOU, 510275, Peoples Rep of China. *Topology of 2D Self-Affine Tiling.*

We give a criterion for the tiles in a self-affine tiling of R^2 to be disk-like, i.e. homeomorphic with a closed disk. As special cases, our criterion includes earlier ones concerning disk-like $\mathbb{Z}^2$-tiles and crystallographic reptiles, and can be applied to substitution tilings and other self-affine tilings. (Received December 30, 2010)

1068-54-43 **Anthony W. Hager*** (ahager@wesleyan.edu), Dept. of Mathematics and Computer Science, Wesleyan University, Middletown, CT 06459, and **Richard N. Ball**. *A frame-theoretic feature of the l-group of Baire functions.*

W is the category of archimedean lattice-ordered groups with weak order unit;the ubiquitous C(X)s are familiar examples."ker" is the functor from W onto Lindelof completely regular frames:kerG is the frame of kernels of W-maps out of G. For an embedding e in W,when is ker(e) an isomorphism,surjection,injection,...? For each of the cases isomorphism,surjection,there is a well-understood maximum such e. However, saying ker(e) is injective puts no bound on the size of the codomain cod(e),so we restrict (somewhat naturally) to epic e and cod(e) having no further epic extension:e is an "epicompletion" (of its domain). The epicompletions of an object G are ordered by:e is above f means he=f for some h (which means cod(f) is a quotient over G of cod(e)). There is a maximum,the epicomplete reflection of G. The embedding b of C(X) into the Baire functions B(X) is an epicompletion of C(X) (which is the maximum when X is compact,otherwise usually not). Theorem. For an epicompletion e of C(X),ker(e) is injective iff e is above b. (We don't know if every W-object has such an epicompletion.) (Received January 05, 2011)

1068-54-44 **Gary D Richardson*** (garyr@mail.ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816, and **Hatim Boustique** (hboustique@valenciacc.edu), Department of Mathematics, University of Central Florida, Orlando, FL. *Lattice-Valued Convergence.* Preliminary report.

Regularity in the category of lattice-valued convergence spaces is defined and studied. This definition is equivalent to that given by W. Gahler in terms of a "compression operator." Given certain restrictions on the lattice, sufficient conditions are listed to ensure that an object possesses a "weakly regular" compactification. Moreover, the closure operator in a compact "symmetric" lattice-valued convergence space is idempotent. (Received January 06, 2011)

1068-54-45 **Hatim Boustique*** (hboustique@valenciacc.edu), Department of Mathematics, Orlando, FL 32816, and **Gary D Richardson** (garyr@mail.ucf.edu), Department of Mathematics, Orlando, FL 32816. *Lattice-Valued Cauchy Spaces.* Preliminary report.

A category of lattice-valued Cauchy spaces is defined, and its properties are investigated. The relationship between this category and the recent work by G. Jäger is presented. The notion of regularity is also studied. In particular, the category consisting of the regular Cauchy spaces is shown to be bireflective in the category of all lattice-valued Cauchy spaces having Cauchy-continuous maps as its morphisms. Moreover, completions of lattice-valued Cauchy spaces are studied. (Received January 06, 2011)

1068-54-53 **Akira Iwasa*** (iwasa@uscb.edu), One university boulevard, Bluffton, SC 29909.
Preservation of convergence to a set under Cohen extensions. Preliminary report.

We say that a sequence of points converges to a set if every neighborhood of the set contains all but finitely many terms of the sequence. We investigate when convergence to a set is preserved under Cohen extensions. (Received January 09, 2011)

1068-54-99 **Zbigniew Piotrowski*** (zpiotr@math.ysu.edu), Dept. of Mathematics and Statistics, 1 University Plaza, Youngstown, OH 44555. *Quasi-continuity and cliquishness on product spaces.*

Abstract. V. Volterra's quasi-continuity turned out to be instrumental in A. Bouziad's generalization of the classical Ellis theorem on semi-topological groups as well as in T. Nagamizu's extension of I. Namioka theorem. Unlike continuity continuity, separate quasi-continuity implies (joint) quasi-continuity, but not vice versa. Despite this, if f is a quasi-continuous (resp. cliquish) function defined on a product of "nice" topological spaces and having values in 2nd countable (resp. weakly developable) space, then almost every, in the sense of category, vertical section is quasi-continuous (resp. cliquish). Also connections to some, yet unpublished, results on cliquishness by A. Bouziad will be given. Most of the results are a part of a joint work with L. Hola and R. Drozdowski (Received January 14, 2011)

1068-54-114 **Francis Jordan** and **Frederic Mynard*** (fmynard@georgiasouthern.edu), Mathematical Sciences, POBox 8093, Statesboro, GA 30460. *Core compactness and diagonality in spaces of open sets.*

We investigate when the space $\mathcal{O}_X$ of open subsets of a topological space X endowed with the Scott topology is core compact. Such conditions turn out to be related to infraconsonance of X, which in turn is characterized in terms of coincidence of the Scott topology of $\mathcal{O}_X \times \mathcal{O}_X$ with the product of the Scott topologies of $\mathcal{O}_X$ at (X, X). On the other hand, we characterize diagonality of $\mathcal{O}_X$ endowed with the Scott convergence and show that this space can be diagonal without being pretopological. New examples are provided to clarify the relationship between pretopologicity, topologicity and diagonality of this important convergence space. (Received January 15, 2011)

1068-54-115 **Szymon Dolecki**, , France, and **Frederic Mynard*** (fmynard@georgiasouthern.edu), Mathematical Sciences, POBox 8093, Statesboro, GA 30460. *A unified theory of function spaces and hyperspaces: local properties.*

Many classically used function space structures (including the topology of pointwise convergence, the compact-open topology, the Isbell topology and the continuous convergence) are induced by a hyperspace structure counterpart. This scheme is used to study local properties of function space structures on $C(X, \mathbb{R})$, such as character, tightness, fan-tightness, strong fan-tightness, the Fréchet property and some of its variants. Under mild conditions, local properties of $C(X, \mathbb{R})$ at the zero function correspond to the same property of the associated hyperspace structure at X. The latter is often easy to characterize in terms of covering properties of X. This way, many classical results are recovered or refined, and new results are obtained. In particular, it is shown that tightness and character coincide for the continuous convergence on $C(X, \mathbb{R})$ and is equal to the Lindelöf degree of X. As a consequence, if X is consonant, the tightness of $C(X, \mathbb{R})$ for the compact-open topology is equal to the Lindelöf degree of X. (Received January 15, 2011)

1068-54-125 **Jack B Brown**, **Zbigniew Piotrowski** and **Russell Waller*** (rwaller@math.fsu.edu), Department of Mathematics, Florida State University, Tallahassee, FL 32306. *Baire and weakly Namioka spaces.*

Recall that a Hausdorff space X is said to be *Namioka* if for every compact (Hausdorff) space Y and every metric space Z, every separately continuous function $f : X \times Y \to Z$ is continuous at each point of $D \times Y$ for some dense G_δ subset D of X. It is a well-known result of J. Saint-Raymond that in the class of all metric spaces, Namioka and Baire spaces coincide. Further it is known that every completely regular Namioka space is Baire and every separable Baire space is Namioka. We study spaces X, we call them *weakly Namioka*, for which the conclusion of Namioka theorem holds provided that the assumption of compactness of Y is replaced by *second countability of* Y. We will prove that in a class of all completely regular spaces, X is Baire if and only if it is weakly Namioka. (Received January 16, 2011)

1068-54-139 **Gary Gruenhage*** (garyg@auburn.edu), Auburn University, Auburn, AL, **Robert Heath**, University of Pittsburgh, Pittsburgh, PA , and **Thomas Poerio**, Univesco, LLC, Pittsburgh, PA. *Cancellative semigroups on Suslin lines.* Preliminary report.

We show that no Suslin line admits a continuous cancellative binary operation. It follows that if a CCC linearly ordered space is a cancellative topological semigroup, it must be metrizable. (Received January 17, 2011)

1068-54-168 **Meredith P Casey***, mcasey@math.gatech,edu. *Branched covers and contact structures.* Preliminary report.

We will discuss what is known about the construction of contact structures via branched covers, emphasizing the search for universal transversal knots. Recall that a topological knot is called universal if all 3-manifold can be obtained as a cover of the 3-sphere branched over that knot. Analogously one can ask if there is a transversal knot in the standard contact structure on S3 from which all contact 3-manifold can be obtained as a branched cover over this transverse knot. It is not known if such a transverse knot exists. (Received January 17, 2011)

1068-54-181 **Heather C Gamel*** (cheatum@email.sc.edu). *D or not D?*

The concept of a D-space was introduced by Eric van Douwen back in the 1970's. The initial concept is not hard: X is a *D-space* if for every neighbornet $\{V_x : x \in X\}$ of X there exists a set $D \subset X$ such that D is closed and discrete and $\cup\{V_d : d \in D\}$ covers X. A set-theoretic tree, T, is said to be *L-special* if there exists a function, $f : T \to L$ such that if $s <_T t$, then $f(s) <_L f(t)$. This talk will discuss for which $\alpha < \omega_1$, $[0,1]^\alpha$-special trees are known to be D-spaces, and which are known to be hereditarily D-spaces. (Received January 18, 2011)

1068-54-188 **Tom Richmond*** (tom.richmond@wku.edu). *Complementation in the Lattice of Locally Convex Topologies.*

We find all locally convex homogeneous topologies on $(\mathbb{R}, \leq)$ and determine which of these have locally convex complements. Among the locally convex topologies on a n-point totally ordered set, each has a locally convex complement, and at least n of them have 2^{n-1} locally convex complements. For any infinite cardinal κ, totally ordered spaces of cardinality κ which have exactly 1, exactly κ, and exactly 2^κ locally convex complements are exhibited. (Received January 18, 2011)

1068-54-199 **Lynne C Yengulalp***, 300 College Park, Dayton, OH 45469. *Non-normality points of $\beta X \setminus X$.*

In 1990, Beslagic and van Douwen showed that, assuming GCH, if X is discrete then both $(\beta X \setminus X) \setminus \{y\}$ and $\beta X \setminus \{y\}$ are not normal for any $y \in \beta X \setminus X$. In 2007, Logunov and Terasawa independently showed (with no extra axioms) that, if X is a crowded metric space, $\beta X \setminus \{y\}$ is not normal for any $y \in \beta X \setminus X$. We combine ideas from these two contexts while seeking conditions implying that $(\beta X \setminus X) \setminus \{y\}$ is not normal for crowded metric spaces. Along the way, we generalize some notions from set-ultrafilters to z-ultrafilters. (Received January 18, 2011)

1068-54-201 **Gary Gruenhage** and **Robert W Heath*** (rwheath@pitt.edu), 1223 Whisper Ridge Rd., Auburn, AL 36830, and **Thomas Poerio**. *Cancellative topological semigroups on Suslin lines II.*

Let G be R^{ω_1} with the lexicograghic order. It was shown by Dieudonne that, under vector addition G is a topological group in which all couintable sets are closed. We show that if there exists a Souslin line, then there there exist a Souslin L that can be embedded in G. We describe two attempts to define an embedding under which a continuous, associative, cancellative operation on L can be induced. Surprisingly enough that cannot be done. (Received January 18, 2011)

1068-54-206 **James Dabbs*** (jamesdabbs@gmail.com). *Some countably compact, countably tight, non-compact spaces.*

We give a simple topological construction of a class of separable, countably compact, countably tight, non-sequential, non-compact spaces which includes spaces first constructed by E. Manes using the concept of a monad. We then mention some applications and generalizations using this construction. (Received January 18, 2011)

1068-54-219 **Vitaly Bergelson**, **Neil Hindman** and **Kendall Williams*** (kendallist@yahoo.com). *Subsets of Elements of Tensor Products of Points in $\beta\mathbb{N}$.* Preliminary report.

A Milliken-Taylor system is a set of the form $MT(\langle a_i\rangle_{i=1}^m, \langle x_n\rangle_{n=1}^\infty) = \{\sum_{i=1}^m a_i \sum_{t\in F_i} x_t : F_1, F_2, \ldots, F_m$ are increasing finite nonempty subsets of $\mathbb{N}\}$, $a_1, a_2, \ldots, a_m \in \mathbb{Z}$, $a_m > 0$, and $\langle x_n\rangle_{n=1}^\infty$ is in $\mathbb{N}$. Given $\langle x_n\rangle_{n=1}^\infty$ in $\mathbb{N}$ and $A \subseteq \mathbb{N}$, there is a sum subsystem $\langle y_n\rangle_{n=1}^\infty$ of $\langle x_n\rangle_{n=1}^\infty$ such that the finite sums of $\langle y_n\rangle_{n=1}^\infty$, $FS(\langle y_n\rangle_{n=1}^\infty) \subseteq A$

if and only if there is an idempotent $p \in \beta\mathbb{N}$, the Stone-Čech Compactification of $\mathbb{N}$, such that $A \in p$ and for each $m \in \mathbb{N}$, $FS(\langle x_n \rangle_{n=m}^{\infty}) \in p$. It has been shown that there is a similar correspondence in which the finite sums are replaced by Milliken-Taylor systems and the set A in question turns out to be an element of a sum of ultrafilters (instead of just the idempotent p). We characterize this situation when A is an element of an arbitrary polynomial in finitely many variables evaluated at points of $\beta\mathbb{N}$. (Received January 18, 2011)

1068-54-293 **Karoline Patricia Null*** (knull@utm.edu), Dept of Mathematics and Statistics, 424 Andy Holt Humanities Building, 209 Hurt Street, Martin, TN 38238. *Sufficient conditions for recognizing a 3-manifold group.*

We ask when a group is a 3-manifold group, or more specifically, when does a group presentation come naturally from a Heegaard diagram for a 3-manifold? We will give some conditions for partial answers to this form of the Isomorphism Problem by addressing how the presentation associated to a diagram for a splitting is related to the fundamental group of a 3-manifold, still using diagrams as a tool to answer these questions. In the process, we determine an invariant of groups (by way of group presentations) for how far such presentations are from 3-manifolds. (Received January 19, 2011)

1068-54-296 **John E Porter*** (ted.porter@murraystate.edu) and **Strashimir G. Popvassilev** (spopvassilev@ccny.cuny.edu). *Monotone Properties Using Stars of Coverings.* Preliminary report.

We define some monotone properties using stars of coverings. This relates to work of V. Tkachik, R. Wilson, J. van Mill, O. Alas, M. Matveev and others who generalized the D-space property of E. van Douwen and E. Michael (they studied non-monotone versions and used stars of open neighborhood assignments). Given a property $\mathcal{P}$, we call a topological space X monotonically star-$\mathcal{P}$ if one can assign to any open cover $\mathcal{U}$ a subspace $s(\mathcal{U}) \subset X$ with property $\mathcal{P}$ in such a way that $\mathrm{St}(s(\mathcal{U}),\mathcal{U}) = \cup\{U \in \mathcal{U} : U \cap s(\mathcal{U}) \neq \emptyset\} = X$ and if $\mathcal{V}$ refines $\mathcal{U}$ then $s(\mathcal{U}) \subset s(\mathcal{V})$. We study monotonically star-$\mathcal{P}$ spaces for various compactness-like properties $\mathcal{P}$ such as finite, compact, and compact metrizable. Other properties $\mathcal{P}$ are considered as well. For example if κ is a regular uncountable cardinal then it is monotonically star-compact but not monotonically star-finite, and is monotonically star-compact-and-metrizable if $\kappa = \omega_1$. (Received January 19, 2011)

1068-54-297 **John Johnson*** (john.j.jr@gmail.com). *topics on the Stone-Cech compactification.*

I will speak on topics on the Stone-Cech compactification (Received January 19, 2011)

1068-54-298 **Laszlo Zsilinszky*** (laszlo@uncp.edu). *On β-favorability of the strong Choquet game.*

In the *strong Choquet game* $Ch(X)$ two players, α and β, take turn in choosing objects in a topological space X: β starts, and always chooses an open set V and a point $x \in V$, then α responds by just an open set U such that $x \in U \subseteq V$. After countably many rounds, α wins the game if the intersection of the chosen open sets is nonempty, otherwise, β wins. *Telgársky* asked whether the existence of a winning strategy for β in $Ch(X)$ is equivalent to the existence of a nonempty W_δ subset of X which is of the 1st category in itself. It will be answered in the positive in 1st countable R_0 spaces, and the non-1st countable case will be also discussed. (Received January 19, 2011)

1068-54-312 **Peter J Nyikos*** (nyikos@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208. *Hereditarily screenable normal, non-paracompact spaces.*

A screenable space is one for which every open cover has an open refinement which is the union of countably many disjoint collections. K. Nagami showed in 1955 that every screenable space whose product with the closed unit interval is normal is paracompact. Using a very complicated procedure involving elementary submodels, Z. Balogh constructed a screenable normal, non-paracompact space.

Two modifications of Balogh's construction will be given, both producing examples of hereditarily screenable, normal, non-paracompact spaces which moreover are the countable union of discrete spaces. (Received January 19, 2011)

57 ► Manifolds and cell complexes

1068-57-1 **Jason A. Behrstock*** (jason.behrstock@lehman.cuny.edu), Department of Mathematics, Lehman College, CUNY, Bronx, NY 10468, and **Walter D. Neumann**, NY. *Quasi-isometric classification of 3-manifold groups.*

Any finitely generated group can be endowed with a natural metric which is unique up to maps of bounded distortion (quasi-isometries). A fundamental question is to classify finitely generated groups up to quasi-isometry.

Considered from this point of view, fundamental groups of 3-manifolds provide a rich source of examples. Surprisingly, a concise way to describe the quasi-isometric classification of 3-manifolds is in terms of a concept in computer science called "bisimulation." We describing this classification and a geometric interpretation of bisimulation. (Received December 22, 2010)

1068-57-3 **Gordana Matic*** (gordana@math.uga.edu), **Ko Honda** and **Will Kazez**. *Contact Structures, Open Books and Contact Invariants in Floer Homology.*

A contact structure on a 3-manifold is a nowhere integrable plane field. Thurston and Winkelnkemper showed in the 70's that an open book decomposition of a 3-manifold determines a compatible contact structure. In 2000 Giroux showed that the converse is true - every contact structure on a 3-manifold is compatible with an open book decomposition. Ozsvath and Szabo used this fact to define an invariant for the contact structure in their Heegaard Floer Homology, providing an important new tool to study contact 3-manifolds. We will describe a simple way to visualize this contact invariant and talk about applications and generalizations. In particular, when the contact manifold has boundary we can define an invariant in Sutured Floer Homology. This is joint work with Ko Honda and Will Kazez. (Received January 19, 2011)

1068-57-118 **Michael Usher*** (usher@math.uga.edu). *Aperiodic symplectic manifolds.*

We describe a general construction which, on a very diverse family of closed manifolds, gives rise to symplectic forms that admit Hamiltonian flows with no nontrivial periodic orbits. In particular, our family includes many of the classic examples of interesting symplectic four-manifolds with $b^+ > 1$. This contrasts with a result of Lu which, when combined with results from Taubes-Seiberg-Witten theory, shows that such symplectic forms can never exist on manifolds with $b^+ = 1$. All this suggests a number of open questions, some of which we will discuss. (Received January 15, 2011)

1068-57-136 **Ben McCarty*** (benm@math.lsu.edu), Department of Mathematics, 303 Lockett Hall, Baton Rouge, LA 70803. *An infinite family of Legendrian torus knots distinguished by cube number.* Preliminary report.

For a knot K the cube number is a knot invariant defined to be the smallest n for which there is a cube diagram of size n for K. There is also a Legendrian version of this invariant called the Legendrian cube number. We will show that the Legendrian cube number distinguishes the Legendrian left hand torus knots with maximal Thurston-Bennequin number and maximal rotation number from the Legendrian left hand torus knots with maximal Thurston-Bennequin number and minimal rotation number. (Received January 17, 2011)

1068-57-158 **Vera Vertesi*** (vertesi@math.mit.edu) and **John Etnyre** (etnyre@math.gatech.edu). *Positive braids are transversaly simple.* Preliminary report.

The standard contact structure in the 3-space is a plane field given by the kernel of the 1-form dz-ydx. A knot whose tangents are transverse to the contact plane field are called transverse, and knots whose tangents lie in the contact plane field are Legendrian. In this talk we describe the building blocks of Legendrian (and transverse) representations of braids in a solid torus, and using these blocks we deduce results about Legendrian and transverse braiding. In particular we prove that positive braids are transversaly simple. This means that a topologically defined invariant (the self linking number) is enough to distinguish transverse representations of any given positive braid. This is a joint work (in progress) with J. Etnyre. (Received January 17, 2011)

1068-57-170 **Christopher Cornwell*** (cornwell@math.msu.edu). *Polynomial invariants and Legendrian links in lens spaces.*

We consider Legendrian links in a lens space with a universally tight contact structure, and the projections of such links to a torus that correspond to toroidal grid diagrams. There is a complexity on such diagrams that we use to find HOMFLY-PT and Kauffman polynomial invariants for links in lens spaces.

This complexity on grid diagrams can also be used to show that a degree of each polynomial fits into a Bennequin-type inequality. As a consequence of the inequality, Legendrian knots with grid number one have maximum Thurston-Bennequin number. (Received January 17, 2011)

1068-57-173 **Allison Gilmore*** (gilmore@math.columbia.edu), NY. *An algebraic proof of invariance for knot Floer homology.*

We investigate the algebraic structure of knot Floer homology in the context of categorification. Ozsváth and Szabó gave the first completely algebraic description of knot Floer homology via a cube of resolutions construction. Starting with a braid diagram for a knot, one singularizes or smooths each crossing, then associates an algebra to each resulting singular braid. These can be arranged into a chain complex that computes knot Floer homology. Using this construction, we give a fully algebraic proof of invariance for knot Floer homology

that avoids any mention of holomorphic disks or grid diagrams. We close with an alternative description of knot Floer homology in terms of Soergel bimodules that suggests a close relationship with HOMFLY-PT homology. (Received January 18, 2011)

1068-57-184 **Evan Fink*** (efink@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602. *Periodic mapping classes and surgery formulas.* Preliminary report.

The Heegaard Floer homology of a 3-manifold obtained by surgery on a knot can be computed from the knot Floer homology of the knot by means of surgery formulas. We use these formulas to compute the Heegaard Floer homology of mapping tori of periodic surface automorphisms, and of manifolds admitting an open book decomposition with periodic monodromy. (Received January 18, 2011)

1068-57-191 **Matt T. Clay**, **Christopher J. Leininger** and **Johanna Mangahas*** (mangahas@math.brown.edu). *The geometry of right angled Artin subgroups of mapping class groups.*

We describe sufficient conditions which guarantee that a finite set of mapping classes generate a right-angled Artin group quasi-isometrically embedded in the mapping class group. Moreover, under these conditions, the orbit map to Teichmüller space is a quasi-isometric embedding for both of the standard metrics. As a consequence, we produce infinitely many genus h surfaces (for any h at least 2) in the moduli space of genus g surfaces (for any g at least 3) for which the universal covers are quasi-isometrically embedded in the Teichmüller space. (Received January 18, 2011)

1068-57-198 **Kenneth L Baker*** (kenken@math.miami.edu), 1365 Memorial Drive, Ungar 515, Coral Gables, FL 33146, and **John B Etnyre** and **Jeremy Van Horn-Morris**. *Cables of Open Books and their Contact Structures.*

Cabling is an operation that transforms an open book into another while preserving the ambient manifold. We study how this operation affects the contact structures supported by these open books. This is done in the generalized context of rational open books where a page may meet a point in the binding with greater multiplicity than 1. Rational open books arise naturally when studying Dehn surgery on fibered knots. (Received January 18, 2011)

1068-57-203 **John B. Etnyre** (shea@math.columbia.edu), New York, 10027, and **David Shea Vela-Vick*** (shea@math.columbia.edu) and **Rumen Zarev**. *Reconstructing* HFK^- *from sutured Floer homology.*

I plan to discuss a method for reconstructing $\mathrm{HFK}^-(Y,K)$ as a direct limit of certain hat homology groups associated to the knot K, each equipped with a naturally defined U-action. Generalizing the techniques used in this construction, one can define useful invariants of contact structures on open 3-manifolds with $\Sigma^2\times[0,\infty)$-ends and appropriate boundary data at infinity. In this talk, I'll focus on the construction and discuss applications if time permits. (Received January 18, 2011)

1068-57-211 **Michael Brad Henry** (mbhenry@math.utexas.edu) and **Dan Rutherford*** (rutherd@math.duke.edu). *A combinatorial Legendrian knot DGA from generating families.* Preliminary report.

A generating family for a Legendrian knot L in standard contact $\mathbb{R}^3$ is a family of functions f_x whose critical values coincide with the front projection of L. Pushkar introduced combinatorial analogs of generating families known as Morse complex sequences which have been studied in connection with augmentations of the Chekanov-Eliashberg DGA by the first author. We will describe how to associate a differential graded algebra (DGA) to a Legendrian knot with chosen Morse complex sequence and discuss the geometric motivation from generating families. (Received January 18, 2011)

1068-57-217 **Margaret Symington***, Department of Mathematics, Mercer University, 1400 Coleman Ave., Macon, GA 31201. *Encoding torus actions: topological, symplectic and Hamiltonian.*

Moment maps provide a very useful way to visualize symplectic manifolds that are equipped with a Hamiltonian torus action. However, further perspective on symplectic manifolds (and near-symplectic manifolds) can be gained by understanding how one can encode the topology of a manifold equipped with a smooth torus action, what constraints are imposed if one assumes that the manifold and the action are symplectic, what symplectic features you can see, and then finally the consequences of the action being Hamiltonian.

This lecture will be at an introductory level and will focus on what can be gleaned from two-dimensional diagrams of four-manifolds about the manifolds themselves and three-manifolds therein, including contact structures on such three-manifolds. (Received January 18, 2011)

1068-57-222 **Bulent Tosun*** (btosun3@math.gatech.edu), 686 Cherry Street School of Mathematics, Ga Tech, Atlanta, GA 30332. *On the Legendrian and transverse classification of cabled knot types.*

In 3-dimensional contact topology one of the classical problem is classifying Legendrian (transverse) knots in certain knot type up to Legendrian (transverse) isotopy. In particular we want to decide if two (one in the case of transverse knots) classical invariants of this knots are complete set of invariants. If it is, then we call this knot type Legendrian (transversely) simple knot type otherwise it is called Legendrian (transversely) non-simple. In this talk, by tracing the techniques developed by Etnyre and Honda, we will present some results concerning the complete Legendrian and transverse classification of certain cabled knots in the standard tight contact 3-sphere. Moreover we will provide an infinite family of Legendrian and transversely non-simple prime knots. Some of these results are joint work with John Etnyre and Douglas LaFountain (Received January 18, 2011)

1068-57-239 **Amey Kaloti*** (ameyk@math.gatech.edu), 686 Cherry St, Atlanta, GA 30332. *Non-loose torus knots.*

Study of legendrian and transverse knots has been central to contact topology. Non-loose(or exceptional) knots (legendrian or transverse), are knots in and overtwisted manifold with tight compliment. In 1995, Eliashberg and Fraser gave a classification of non-loose unknot. In this talk we will try to give a similar classification result for torus knots (specifically trefoil). This is a join work with John Etnyre. (Received January 19, 2011)

1068-57-242 **Steven Sivek*** (ssivek@math.mit.edu), 77 Massachusetts Ave., Room 2-089, Cambridge, MA 02139. *A bordered Chekanov-Eliashberg algebra.*

The Chekanov-Eliashberg invariant of a Legendrian knot is a differential graded algebra determined by a front diagram. Using ideas from bordered Heegaard Floer homology, we can break such a diagram into several pieces and assign a DGA to each so that the knot invariant can be recovered by a pairing theorem analogous to the van Kampen theorem. We will apply this technique to construct morphisms between the DGAs of fronts related by Legendrian tangle replacements and to compute the linearized contact homology of Legendrian Whitehead doubles. (Received January 19, 2011)

1068-57-272 **Ina Petkova*** (ina@math.columbia.edu). *Properties of the bordered Floer complex and applications to knot theory.*

We describe bordered Floer homology, defined by Lipshitz, Ozsvath, and Thurston. Then we discuss some properties of the bordered Floer complex in the case of torus boundary, focusing on some applications to satellites of knots. (Received January 19, 2011)

1068-57-310 **Sang-hyun Kim*** (shkim@kaist.edu) and **Sang-il Oum** (sangil@kaist.edu). *Hyperbolic surface subgroups of one-ended doubles of a free groups.*

By a double of a free group, we mean the graph of groups where there are two isomorphic free vertex groups and a cyclic edge group amalgamated via the same map. We prove that a one-ended double of a free group contains a hyperbolic surface group if the rank of the free group is two or if each generator of the free group appears the same number of times in the amalgamating word. (Received January 19, 2011)

58 ► Global analysis, analysis on manifolds

1068-58-132 **Jeehyeon seo*** (meshgrid80@gmail.com), 1409 W. Green Street, Urbana, IL 61801. *Bi-Lipschitz embeddability of the Grushin plane into Euclidean space.*

Many sub-Riemannian manifolds like the Heisenberg group do not admit bi-Lipschitz embedding into any Euclidean space. In contrast, the Grushin plane admits a bi-Lipschitz embedding into some Euclidean space. This is done by extending a bi-Lipschitz embedding of the singular line, using a Whitney decomposition of its complement. (Received January 16, 2011)

1068-58-178 **Robert S. Strichartz** (str@math.cornell.edu), Department of Mathematics, Cornell University, Ithaca, NY 14853, and **Alexander Teplyaev*** (teplyaev@uconn.edu), Department of Mathematics, University of Connecticut, Storrs, CT 06269. *Spectral analysis on infinite Sierpinski fractafolds.*

A fractafold, a space that is locally modeled on a specified fractal, is the fractal equivalent of a manifold. For compact fractafolds based on the Sierpinski gasket, it was shown by the first author how to compute the discrete spectrum of the Laplacian in terms of the spectrum of a finite graph Laplacian. A similar problem was solved by the second author for the case of infinite blowups of a Sierpinski gasket, where spectrum is pure point of infinite

multiplicity. Both works used the method of spectral decimations to obtain explicit description of the eigenvalues and eigenfunctions. In this paper we combine the ideas from these earlier works to obtain a description of the spectral resolution of the Laplacian for noncompact fractafolds. Our main abstract results enable us to obtain a completely explicit description of the spectral resolution of the fractafold Laplacian. For some specific examples we turn the spectral resolution into a "Plancherel formula". We also present such a formula for the graph Laplacian on the 3-regular tree, which appears to be a new result of independent interest. In the end we discuss periodic fractafolds and fractal fields. (Received January 18, 2011)

60 ► Probability theory and stochastic processes

1068-60-62 **Ka-Sing Lau*** (kslau@math.cuhk.edu.hk), Department of Mathematics, The Chinese University of Hong Kong, Hong Kong, and **Sze-Man Ngai** (smngai@georgiasouthern.edu), Department of Mathematical Sciences, Goergia Southern University, Stateboro, GA 30460-8093. *Self-similar sets and Martin boundaries.* Preliminary report.

We consider Markov chains on the symbolic space of a self-similar set K. The general problem is to identify the Martin boundary with K, which allows a natural harmonic structure on K. In particular we introduce a Markov chain on the Sierpinski gasket so that the Martin boundary is homeomorphic to the SG and the minimal boundary is the three vertices; the harmonic structure coincides with that by Kigami. This offers an alternative approach to study the existence of Laplacian on the self-similar sets. (Received January 11, 2011)

1068-60-257 **Suman Sanyal*** (sanyal@marshall.edu), 25755-2560, and **Bonita Lawrence** (lawrence@marshall.edu), Department of Mathematics, Marshall University, Huntington, WV 25755-2560. *Parameter estimation of dynamic Langevin's equation and related problems.* Preliminary report.

In this talk, we introduce dynamic Langevin's equation

$$\Delta X = -\alpha X \Delta t + \beta \Delta W(t),$$

where X is a stochastic process indexed by a time scale, W is a one-dimensional Brownian motion, and α, β are constants. We present certain results related to the estimation of the parameters α and β when $t \in \mathbb{T}$, where $\mathbb{T}$ is a time scale, i.e., a closed subset of the reals. (Received January 19, 2011)

1068-60-273 **Ezra Miller*** (ezra@math.duke.edu). *Sticky central limit theorems on polyhedral spaces.* Preliminary report.

Certain singular spaces, including polyhedral complexes such as "tree spaces" that parametrize metric phylogenetic trees on fixed sets of taxa, increasingly arise as sample spaces in modern statistics problems. (This is distinct from algebraic statistics, where potentially singular spaces typically parametrize models, not sample points.) Applications to areas such as biology, medicine, and image analysis require understanding the asymptotics of distributions on such spaces. In the surprisingly common circumstance when Fréchet (intrinsic) means of distributions on polyhedral spaces lie on faces of low dimension, central limit theorems can exhibit non-classical "sticky" behavior: positive mass can be supported on thin subsets of the ambient space. This talk reports on current investigations by a Working Group at the Statistical and Applied Mathematical Sciences Institute (SAMSI) program on Analysis of Object Data. (Received January 19, 2011)

1068-60-343 **Xiaoping Shen*** (shenx@ohio.edu), 571 Morton Hall, Department of Mathematics, 1 Ohio University, Athens, OH 45701. *Sparse statistical data analysis based on the L1-norm - case study.* Preliminary report.

In this talk, we report our recent study on constructing a probability model for sparse data related to complex system. Numerical experiments based on simulated data and field data are presented. (Received January 21, 2011)

62 ► Statistics

1068-62-9 **Godday Uwawunkonye Ebuh** (ablegod007@yahoo.com), Department of Statistics, Faculty of Physical Sciences, Nnamdi Azikiwe University, Awka, +23448, Nigeria, and **Chidinma Nwoke*** (ablegod007@yahoo.com), Department of Statistics, Faculty of Physical Sciences, Nnamdi Azikiwe University, Awka, +23448, Nigeria. *Statistical Modeling of Wastage Using the Beta Distribution.*

This work attempts to fit a set of observed industrial wastage to the beta distribution using the chi-square goodness of fit test and it was found to fit the Beta distribution at 1% significance level. The mean and the variance of the wastage proportion were found to be 0.429 and 0.0395 respectively. The parameters of the Beta distribution were α= 2 and $\beta = 3$. The skewness of the Beta distribution is 0.286 confirming the claim that the distribution is skewed to the left whenever $\beta > \alpha$ and the distribution is a unimodal distribution since α and β is greater than 1. (Received October 22, 2010)

65 ► Numerical analysis

1068-65-224 **Alexander Petukhov*** (petukhov@math.uga.edu), DEPARTMENT OF MATHEMATICS, University of Georgia, Athens, GA 30622, and **Inna Kozlov** (kozlovinna@yahoo.com), 1191 Holcomb Ct, Bogart, 30622. *Image and video denoising by means of representations with hornlets.*

The mainstream idea for image model used for image processing claims that an image essentially is a piecewise smooth function and edges of the pieces are also piecewise smooth curves. Taking this conjecture as a start point, many systems for sparse representations of images along objects edges were invented. Among them curvelets, bandlets, contourlets, and shearlets are most popular.

We consider one more very redundant system of functions which we call "hornlets". This system gives very flexible tool for image representation. It can be used not only for denoising but also for very challenging modern problems like video up-sampling and change the frame rate. (Received January 18, 2011)

1068-65-254 **Simon Foucart*** (foucart@math.drexel.edu), 269 Korman Center, Department of Mathematics, Drexel University, 3141 Chestnut Street, Philadelphia, PA 19104. *Hard Thresholding Pursuit for Sparse Reconstruction.*

We introduce a new iterative algorithm to find s-sparse solutions $\mathbf{x} \in \mathbb{C}^N$ of underdetermined linear systems $A\mathbf{z} = \mathbf{y}$, $A \in \mathbb{C}^{m\times N}$, $\mathbf{y} \in \mathbb{C}^m$. The algorithm, which is a simple combination of existing Compressive Sensing algorithms, is called Hard Thresholding Pursuit. We study its convergence to notice that only a finite number of iterations are required. We then give a short and elegant proof of the fact that, under a certain restricted isometry condition on the matrix A, every s-sparse vector is exactly recovered as the output of the algorithm with uncorrupted input $\mathbf{y} = A\mathbf{x} \in \mathbb{C}^m$. The condition, namely that $3s$th order restricted isometry constant satisfies $\delta_{3s} < 1/\sqrt{3}$, is heuristically better than the sufficient conditions currently available for other Compressive Sensing algorithms. Next, we extend the result to non-sparse vectors and to corrupted inputs. We conclude by discussing some variations of the algorithms. (Received January 19, 2011)

1068-65-276 **C Jagels**, Department of Mathematics, Hanover, IN 47243, and **L Reichel*** (reichel@math.kent.edu), Department of Mathematics, Kent, OH 44242. *Structured matrices in rational Gauss quadrature.*

We are concerned with the approximation of matrix functionals defined by a large, sparse or structured, symmetric definite matrix. These functionals are Stieltjes integrals with a measure supported on a compact real interval. Rational Gauss rules that are designed to exactly integrate Laurent polynomials with a fixed pole in the vicinity of the support of the measure may yield better approximations of these functionals than standard Gauss quadrature rules with the same number of nodes. It therefore can be attractive to approximate matrix functionals by these rational Gauss rules. We describe the structure of the matrices associated with these quadrature rules and discuss computational aspects. (Received January 19, 2011)

1068-65-280 **Qinian Jin*** (qnjin@math.vt.edu), Department of Mathematics, Virginia Tech, Blacksburg, VA 24061. *Newton type regularization methods for solving nonlinear inverse problems.*

I will present my recent work on some Newton type regularization methods for solving nonlinear inverse problems which are in general ill-posed. We consider the discrepancy principle to terminate the iterations and establish the order optimal convergence results. (Received January 19, 2011)

1068-65-284 **Isom Jurayev*** (ijurayev@yahoo.com), 10021 Whitemark Lane, Cary, NC 27511. *Gauss Elimination is the Best.*

We consider a variation of the Gauss Elimination for solving Linear Systems. Here we would like to note only the following of its important features: by the number of operations performed is the best method; no observed accumulation of rounding errors; no need to calculate the determinant; easily adapted to parallelization. The theoretical findings are confirmed by numerical experiment conducted on the basis of IDE Borland Turbo C + + Explorer Edition for Windows. In particular, even for ILL - Conditioned Linear Equations with Hilbert matrix [1] of order 250, we obtained an expected solution. [1] J. H. Wilkinson, The Solution of ILL - Conditioned Linear Equations, p.65-94, A. Ralston and H. S. Wilf, Mathematical Methods for Digital Computers, vol.II, Wiley (1967). (Received January 19, 2011)

1068-65-329 **Muhammet Kurulay*** (muhammet.kurulay@uconn.edu), 33 stone ridge, Mansfield, CT 06252. *A note on fractional derivatives and Laplace's transform of fractional order.*

We study definition of a fractional Laplace's transform, or Laplace's transform of fractional order, which applies to functions which are fractional differentiable.After a short survey on fractional analysis based on Riemann–Liouville derivative, we define the fractional Laplace's transform.Fractional comparison principle is introduced and the application of Riemann–Liouville fractional order is extended by using Caputo fractional order . The presented results are illustrated by analyzing some examples to demonstrate the effectiveness of the presented analytical approaches. (Received January 20, 2011)

1068-65-344 **Richard S Varga*** (varga@math.kent.edu) and **A Rizzo**. *An Application of Nonnegative Matrices to the Synchronization of Chaotic Oscillators.*

For any positive integer k, let $B = [b_{i,j}]$ in $R^{m,m}$, where $m \geq k+1$, have entries satisfying

$$b_{i,i} = 0 \text{ (all } 1 \leq i \leq m); \tag{1}$$

$$b_{i,j} = 0 \text{ or } 1 \text{ (all } i \neq j,\ 1 \leq i,j \leq m); \tag{2}$$

$$\sum_{j=1}^{m} b_{i,j} = k \text{ (all } 1 \leq i \leq m); \tag{3}$$

and let $\mathfrak{B}(k)$ denote the set of all $m \times m$ matrices satisfying $(1)-(3)$, with $m \geq k+1$. We show here that

$$\overline{\bigcup_{B \in \mathfrak{B}(1)} \sigma(B)} = \{0\} \cup \{z \in C : |z| = 1\},$$

and

$$\overline{\bigcup_{B \in \mathfrak{B}(k)} \sigma(B)} = \{z \in C : |z| \leq k\}, \text{ for all } k \geq 2.$$

We also show graphically how the eigenvalues of $\mathfrak{B}(k)$ fill out the associated disk, for $k \geq 2$. (Received January 21, 2011)

1068-65-345 **Michael Eiermann*** (ermann@math.tu-freiberg.de). *On Krylov subspace methods for matrix functions.*

Transient electromagnetics is a geophysical exploration method to determine subsurface electrical and magnetic properties. Its application requires the solution of an inverse problem for a Maxwell's equation. The corresponding forward problem is closely linked to the computation of $f(A)\mathbf{b}$, where $A \in \mathbb{C}^{n\times n}$, $\mathbf{b} \in \mathbb{C}^n$, and $f(\lambda) = f_t(\lambda) = e^{t\lambda}$ is the exponential function with time acting as a parameter t.

Here and in other applications the matrix A is large and sparse or structured, typically resulting from discretization of an infinite-dimensional operator. In this case evaluating $f(A)\mathbf{b}$ by first computing $f(A)$ is usually unfeasible. The standard approach for approximating $f(A)\mathbf{b}$ directly is based on a Krylov subspace of A with initial vector $\mathbf{b}$. The advantage of this approach is that it requires A only for computing matrix-vector products and that it converges superlinearly for the exponential function. In this talk we review recent activities in this area and emphasize related open problems. (Received January 21, 2011)

68 ► Computer science

1068-68-70 **Isom Jurayev*** (ijurayev@yahoo.com), 10021 Whitemark Lane, Cary, NC 27511. *New efficient searching and sorting algorithms.* Preliminary report.

New efficient algorithm generated for searching the number a among ordered numbers $a_i, i = 1, 2, \ldots, n < \infty$. At $a_i - a_{i-1} = const$ a problem of searching is solved immediately. Also new efficient sorting algorithm of numbers $a_i, i = 1, 2, \ldots, n < \infty$ requiring $O(n)$ operations is created . The proposed algorithms are tested in

the IDE Borland Turbo C + + Explorer Edition for Windows. The numerical results confirm the simplicity and effectiveness of the proposed searching and sorting algorithms. (Received January 11, 2011)

1068-68-278 **Hongwei Wu*** (hongwei.wu@gatech.edu), 210 Technology Circle, Savannah, GA 31407.
Spectral Clustering for Detecting Modules from the Functional Protein Association Networks of Bacteria. Preliminary report.

Presence of clusters is one of the properties shared by many real-world networks, where within the same cluster nodes are densely connected and between clusters nodes are sparsely connected. Detecting clusters has significant implications in many fields. For example, modules in gene regulatory networks often correspond to function units of the cellular machinery to fulfill certain biological objectives, and therefore often render contextual information for drug designs. Several methods have been developed for detecting clusters of a network, among which spectral clustering has recently emerged particularly effective, because (1) it does not necessarily rely on topological properties of the network and can therefore be applied to a broad spectrum of networks, (2) the natural clusters in the data do not necessarily correspond to convex regions, (3) its optimality has been theoretically proved and empirically demonstrated, and, (4) it is easy to implement. Here we apply spectral clustering to functional module detection of biological networks. We investigate the functional protein association networks of six bacterial model organisms and discuss how the parameter of spectral clustering can be tuned to render functionally and evolutionarily relevant modules. (Received January 19, 2011)

70 ► Mechanics of particles and systems

1068-70-288 **Doug Hardin*** (doug.hardin@vanderbilt.edu), **Ed Saff** and **Tyler Whitehouse**.
Separation and mesh-norm estimates for minimal weighted energy points on compact metric spaces.

Let A be an α-regular compact metric space with metric m (for example, A could be a self-similar set with Hausdorff dimension α). For a set of N points $\omega_N = \{x_1, \dots x_N\} \subset A$; we consider the *separation distance of* ω_N given by

$$\delta(\omega_N) := \min_{1 \le i \ne j \le N} (x_i, x_j),$$

and the *mesh norm* (or *covering radius*) *of* ω_N *with respect to* A defined by

$$\rho(\omega_N, A) := \max_{y \in A} \min_{1 \le i \le N} (y, x_i).$$

A sequence $\{\omega_N\}_{N=2}^{\infty}$ of N-point configurations in A is said to be *quasi-uniform* if the *mesh ratio*

$$\gamma(\omega_N, A) := \rho(\omega_N, A)/\delta(\omega_N)$$

is bounded independent of N.

For $s > \alpha$ and an SLP weight w on $A \times A$, let $\omega_N^* := \{x_1^*, \dots, x_N^*\} \subset A$ denote a collection of N points in A that minimize the weighted energy

$$\sum_{i \ne j} \frac{w(x_i, x_j)}{m(x_i, x_j)^{-s}},$$

over all N-point configurations in A. We prove that the sequence $\{\omega_N\}_{N=2}^{\infty}$ is quasi-uniform.

Our results extend separation results of Borodachov, Hardin and Saff and extend mesh norm estimates of Damelin and Maymeskul. (Received January 19, 2011)

90 ► Operations research, mathematical programming

1068-90-38 **Lijian Chen** (lijian.chen@louisville.edu), 5241 Craigs Creek Dr., Louisville, KY 40241, and **Qingbin Cui*** (cui@umd.edu), University of Maryland, College Park, MD 21250.
Structuring Public Private Partnership in Transportation Infrastructure, A Stochastic Optimization Approach.

The public private partnership for transportation infrastructure is established through contractual agreements, long term maintenance contracts, and long term leases to essentially outsource some traditional government functions to private partners in order to finance the transportation infrastructure, downsize government, and control spending. We propose a convex optimization method by affine controllers to mathematically solve the multi-stage model. (Received December 31, 2010)

1068-90-83 **Haw-ren Fang*** (hrfang@cs.umn.edu) and **Dianne P O'Leary** (oleary@cs.umd.edu). *Euclidean Distance Matrix Completion Problems.* Preliminary report.

A Euclidean distance matrix is one in which the (i,j) entry specifies the squared distance between particle i and particle j. Given a partially-specified symmetric matrix A with zero diagonal, the Euclidean distance matrix completion problem (EDMCP) is to determine the unspecified entries to make A a Euclidean distance matrix.

We survey three different approaches to solving the EDMCP. We advocate expressing the EDMCP as a nonconvex optimization problem using the particle positions as variables and solving using a modified Newton or quasi-Newton method. To avoid local minima, we develop a randomized initialization technique that involves a nonlinear version of the classical multidimensional scaling, and a dimensionality relaxation scheme with optional weighting.

Our experiments show that the method easily solves the artificial problems introduced by Moré and Wu. It also solves the 12 much more difficult protein fragment problems introduced by Hendrickson, and the 6 larger protein problems introduced by Grooms, Lewis, and Trosset. (Received January 13, 2011)

1068-90-87 **Fatma Kilinc-Karzan***, 765 Ferst Drive NW, Atlanta, GA 30332, and **Arkadi Nemirovski** and **Anatoli Juditsky**. *ℓ_1 Minimization via Randomized First Order Algorithms.*

We propose a randomized first-order algorithm to solve bilinear saddle points problems. Our developments are motivated by the need for sublinear time algorithms to solve large-scale parametric bilinear saddle point problems where cheap online assessment of solution quality is crucial. We present the theoretical efficiency estimate of our algorithm and discuss a number of applications, primarily to the problem of ℓ_1 minimization arising in sparsity-oriented signal processing. We demonstrate both theoretically and numerically, that when seeking medium-accuracy solutions of large-scale ℓ_1 minimization problems, our randomized algorithm outperforms significantly (and progressively as the sizes of the problem grow) the state-of-the art deterministic methods. (Received January 13, 2011)

1068-90-95 **Roman Sznajder*** (rsznajder@bowiestate.edu), Department of Mathematics, Bowie State University, Bowie, MD 20715-9465. *A norm P-property for linear transformations on Euclidean Jordan algebras.* Preliminary report.

In their recent paper, Chua and Yi introduced a norm P-property, called the uniform nonsingularity property (UNS-property), of a nonlinear transformation on a Euclidean Jordan algebra and showed that this property implies the global uniqueness property (GUS-property) in the context of symmetric cone complementarity problems. In a related paper, Chua, Lin and Yi raise the question of converse. In this talk, we show that for linear transformations, UNS-property is inherited by principal subtransformations, and on simple algebras, it is invariant under the action of cone automorphisms. As a consequence, we show that on simple algebras, the UNS-property implies the so-called ultra P-property which further implies the GUS-property. Based on these results, we answer the question of Chua, Lin and Yi in the negative. (Received January 14, 2011)

1068-90-98 **Meiyun Y. He** (myhe@umd.edu) and **Andre L. Tits*** (andre@umd.edu). *Infeasible Constraint-Reduced Interior-Point for Linear Optimization.*

Constraint-reduction schemes have been proposed for the solution by interior-point methods of linear programs with many more inequality constraints than variables in standard dual form. Such schemes have been shown to be provably convergent and highly efficient in practice. A critical requirement of these schemes is the availability of an initial dual-feasible point.

In this paper, building on a general framework for dual-feasible constraint-reduced interior-point optimization, we propose a framework for "infeasible" constraint-reduced interior-point optimization. Central to this framework is an exact (ℓ_1 or ℓ_∞) penalty function scheme endowed with a mechanism for iterative adjustment of the penalty parameter. Finiteness of the sequence of penalty parameter adjustments is proved under mild assumptions for all algorithms that fit within the framework, including "infeasible" extensions of a "dual" algorithm proposed in the early 1990s and of two recently proposed "primal-dual" algorithms. Finally, for the case of a constraint-reduced variant of Mehrotra's Predictor-Corrector algorithm, further convergence results are proved, and numerical results are reported that demonstrate that the approach is of practical interest. (Received January 14, 2011)

1068-90-149 **Gabor Pataki*** (gabor@unc.edu), Dept of Statistics and Operations Research, Hanes Hall 307, UNC Chapel Hill, Chapel Hill, NC 27516. *Bad semidefinite programs: they all look the same.*

A dual solution serves as a certificate of optimality in semidefinite programming, so it is important to understand when such certificates are not available. We say that the semidefinite system (spectrahedron) P is *badly behaved*,

if for some linear objective function "c" the value $\sup\{cx : x \in P\}$ is finite, but the dual program has no solution attaining the same value.

We give simple, and exact characterizations of badly behaved semidefinite systems. Surprisingly, it turns out that a certain system with one variable, and two by two matrices appears as a minor in all badly behaved systems in a well-defined sense. The main tool we use is one of our recent results, that characterizes when the linear image of a closed convex cone is closed.

We give similar characterizations of badly behaved second order conic systems. While we use convex analysis, the characterizations have a combinatorial flavor. (Received January 17, 2011)

1068-90-229 **Sanjay Mehrotra*** (mehrotra@iems.northwestern.edu), IEMS Department, Evanston, IL 60208, and **Kuo-Ling Huang**, Evanston, IL 60208. *Computational Experience with a Modified Potential Reduction Algorithm for Linear Programming.* Preliminary report.

We study the performance of a homogeneous and self-dual interior point solver for linear programming that is equipped with a a continuously differentiable potential function. Our work is motivated by the apparent gap between the theoretical complexity results and long-step practical implementations in interior point algorithms. The potential function described here ensures a global linear polynomial-time convergence while providing the flexibility to integrate heuristics for generating the search directions and step length computations. Computational results on standard test problems show that LP problems are solved as effectively (in terms of the number of iterations) as Mosek6. (Received January 18, 2011)

1068-90-231 **Goran Lesaja*** (goran@georgiasouthern.edu), Department of Mathematical Sciences, Georgia Southern University, 203 Georgia Ave., Statesboro, GA 30460-8093. *Kernel-Based Interior-Point Methods for Cartesian $P_*(\kappa)$-Linear Complementarity Problems over Symmetric Cones.*

We present an interior-point method (IPM) for Cartesian $P_*(\kappa)$- Linear Complementarity Problems over Symmetric Cones (SCLCPs). The Cartesian $P_*(\kappa)$- SCLCPs have been recently introduced as the generalization of the more commonly known and more widely used monotone SCLCPs. The IPM is based on the barrier functions that are defined by a large class of univariate functions called eligible kernel functions which have recently been successfully used to design new IPMs for various optimization problems. Eligible barrier (kernel) functions are used in calculating the Nesterov-Todd search directions and the default step-size which leads to very good complexity results for the method. For some specific eligible kernel functions we match the best known iteration bound for the long-step methods while for the short-step methods the best iteration bound is matched for all cases. (Received January 18, 2011)

1068-90-234 **Camilo Ortiz*** (camiort@gatech.edu), School of Industrial and Systems Engineering, Georgia Institute of Technology, 765 Ferst Drive, NW, Off. 325, Atlanta, GA 30332-0205, **Renato D.C. Monteiro** (monteiro@isye.gatech.edu), School of Industrial and Systems Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0205, and **Benar F. Svaiter** (benar@impa.br), IMPA, Estrada Dona Castorina 110, Rio de Janeiro, 22460-320, Brazil. *Implementation of a Block Decomposition Algorithm for Solving Large-Scale Conic Optimization Problems.*

A recent work by Monteiro and Svaiter (2010) studied the iteration complexity of block decomposition methods for solving monotone variational inequalities and convex optimization problems. In this talk we review these methods and their corresponding complexity bounds. We also report very encouraging computational results comparing our methods with the second order algorithm SDPNAL (X. Zhao, D. Sun, and K. Toh) and the boundary point method introduced by J. Povh, F. Rendl, and A. Wiegele. The results obtained on a varied collection of large scale conic problems consisting of both nonnegative vector and/or positive semidefinite matrix variables are quite promising. (Received January 19, 2011)

92 ► Biology and other natural sciences

1068-92-42 **Fan Deng** (enetoremail@gmail.com), Athens, GA 30602, and **Tianming Liu***, Boyd GSRC 415, Athens, GA 30602. *Empirical Mean Curve Decomposition for fMRI Signal Processing.*

FMRI blood-oxygenation level dependent (BOLD) signal is characterized by its non-linearity, non-stationarity and composition of signal components at multiple time scales, which imposes significant challenges to inferring meaningful information from it. In responses, we present a novel data-driven multi-scale signal decomposition

framework named Empirical Mean Curve Decomposition (EMCD) that iteratively extracts mean envelope components from fMRI signals for the purpose of functional brain mapping. The EMCD approach has been applied in three significant fMRI applications including task-based fMRI for activation detection, resting state fMRI for functional connectivity analysis, and natural stimulus fMRI for correlation analysis of multimedia feature curves and fMRI signals. (Received January 03, 2011)

1068-92-66 **Michael Malisoff*** (malisoff@lsu.edu), Department of Mathematics, 303 Lockett Hall, Louisiana State University, Baton Rouge, LA 70803-1948. *Controlling Human Heart Rate Response During Treadmill Exercise.*

We study a recently developed nonlinear model of human heart rate response during treadmill exercise. The state variables are the deviation of the heart rate from the at-rest rate, and an internal state representing local peripheral effects. The controller is the speed of the treadmill. We design controllers and observers that stabilize prescribed heart rate profiles. Our designs can be applied even when the internal state is not available for measurement and are robust to uncertainty in the model parameters and to variation of the treadmill speed from the controller values. This work is joint with Frederic Mazenc and Marcio de Queiroz. (Received January 20, 2011)

1068-92-82 **Yangbo Ye*** (yey@iowa.uiowa.edu), Department of Mathematics, The University of Iowa, Iowa City, IA 52242-1419. *Gel'fand-Graev's reconstruction formula in a 3D real space.*

Gel'fand and Graev performed classic work on inversion formulas of integral transforms in different spaces and revealed a fundamental relationship between projection data and the Hilbert transform of an image to be reconstructed. This relationship was re-discovered in the computed tomography field, and applied to truncated reconstruction, backprojection filtration (BPF), interior tomography, and limited-angle tomography. In this talk we will explain Gel'fand-Graev's inversion formula for the 1D x-ray transform in a 3D space and show that the BPF algorithm is a special case of Gel'fand-Graev's formula. (Received January 13, 2011)

1068-92-182 **Jiehua Zhu***, Department of Mathematical Sciences, Georgia Southern University, Statesboro, GA 30460, and **Xiezhang Li**. *A Block Diagonally-Relaxed Orthogonal Projection Algorithm for Computed Tomography.*

The theory of compressed sensing has recently shown that signals and images that have sparse representations in some orthonormal basis can be reconstructed from much less data, at high quality, than what the Nyquist sampling theory requires. In this talk, we will introduce a block diagonally-relaxed orthogonal projection algorithm for computed tomography image reconstruction in the compressed sensing framework and derive its convergence. (Received January 18, 2011)

1068-92-197 **Yingkang Hu*** (yhu@georgiasouthern.edu), Dept of Mathematical Sciences, PO Box 8093, Georgia Southern University, Statesboro, GA 30460-8093, and **Jiehua Zhu** (jzhu@georgiasouthern.edu). *High-Degree Polynomial Models for CT Simulation.*

We implement on the computer polynomial surface classes $f(x, y, z) = 0$ for computer graphics modeling. They have various general forms with arbitrary total degree $n \geq 0$. Most of them can have many more parameters than their degree, which make their shape highly flexible. We are using them to build equation-based digital phatoms and compute the x-ray transform for computed tomography (CT) simulation. (Received January 18, 2011)

1068-92-226 **Maiko Arichi*** (ma30@zips.uakron.edu), Department of Theoretical and Applied Math, Buchtel College of Arts and Sciences, The University of Akron, Akron, OH 44325-4002. *Real-time Ischemic Detection from Electrocardiograms using the Dilated,Discrete Hermite Transform.*

An automated identification technique was developed for the detection of ischemic episodes in long term electrocardiographic (ECG) signals using mathematical expansions involving the discrete dilated Hermite Transform. The discrete Hermite functions are generated as eigenvectors of a symmetric tridiagonal matrix that commutes with the centered Fourier matrix. The Hermite transform values are computed from a simple dot product between an individual ECG complex extracted from the European Society of Cardiology (ESC) ST-T database and the corresponding discrete Hermite function. These values are found to contain information about the ECG shape, highlighting changes between ST-segment deviation and T-wave alterations which are the features of ischemic episodes. This information from the discrete Hermite transform, based on an orthonormal set of n-dimensional digital Hermite functions that serve as shape-identification functions, can be used to identify ischemic episodes from the ECG. (Received January 18, 2011)

1068-92-289 **Bruce P. Ayati*** (bruce-ayati@uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52245, and **Claire M. Edwards**, **Glenn F. Webb** and **John P. Wikswo**. *A mathematical model of bone remodeling dynamics for normal bone cell populations and myeloma bone disease.*

Background: Multiple myeloma is a hematologic malignancy associated with the development of a destructive osteolytic bone disease.

Results: Mathematical models are developed for normal bone remodeling and for the dysregulated bone remodeling that occurs in myeloma bone disease. The models examine the critical signaling between osteoclasts (bone resorption) and osteoblasts (bone formation). The interactions of osteoclasts and osteoblasts are modeled as a system of differential equations for these cell populations, which exhibit stable oscillations in the normal case and unstable oscillations in the myeloma case. In the case of untreated myeloma, osteoclasts increase and osteoblasts decrease, with net bone loss as the tumor grows. The therapeutic effects of targeting both myeloma cells and cells of the bone marrow microenvironment on these dynamics are examined.

Conclusions: The current model accurately reflects myeloma bone disease and illustrates how treatment approaches may be investigated using such computational approaches. (Received January 19, 2011)

93 ► Systems theory; control

1068-93-12 **Charoenchit Panpetia***, 39/1 Mooo1. Klong_hae, Hatyai, Songkhla 90110, Thailand. *Theory of Controllity: The relationship between the function and motion of objects.*

There is no difference between displacements of two objects during the same time interval if the displacement of one is zero. This relationship between two objects is called the Controllity. (Received October 25, 2010)

1068-93-39 **Aleksandra Gruszka*** (olka@math.lsu.edu), Department of Mathematics, 303 Lockett Hall, Louisiana State University, Baton Rouge, LA 70803-4918. *Tracking Control and Robustness for Planar Vertical Takeoff and Landing Aircraft under Bounded Feedbacks.*

We study feedback tracking for the planar vertical takeoff and landing aircraft dynamics, which is a benchmark model in aerospace engineering. We construct new feedback stabilizers for the tracking dynamics. The novelty of our contribution is in the boundedness of our feedback controllers and their applicability to cases where the velocity measurements may not be available, coupled with the uniform global asymptotic stability and uniform local exponential stability of the closed loop tracking dynamics, and the input-to-state stable performance of the closed loop tracking dynamics with respect to actuator errors. Our proofs are based on a new bounded backstepping result. This work is joint with Michael Malisoff and Frederic Mazenc. (Received January 03, 2011)

1068-93-40 **Michael Malisoff*** (malisoff@lsu.edu), Department of Mathematics, 303 Lockett Hall, Louisiana State University, Baton Rouge, LA 70803-4918. *Uniform Global Asymptotic Stability of Adaptive Cascaded Nonlinear Systems with Unknown High-Frequency Gains.*

We study adaptive tracking problems for nonlinear systems with unknown control gains. We construct controllers that yield uniform global asymptotic stability for the error dynamics, hence tracking and parameter estimation for the original systems. Our result is based on a new explicit, global, strict Lyapunov function construction. We illustrate our work using a brushless DC motor turning a mechanical load. We quantify the effects of time-varying uncertainties on the motor electric parameters using integral input-to-state stability. This work is joint with Frederic Mazenc and Marcio de Queiroz. (Received January 03, 2011)

1068-93-79 **Ahmet Ozkan Ozer*** (oozer@iastate.edu), 403 Carver Hall Department of Mathematics, Iowa State University, Ames, IA 50011. *Exact boundary controllability results for a multi-layer Rao-Nakra Beam.*

The boundary controllability problem for a multi-layer Rao-Nakra sandwich beam is considered. This beam system consists of a Rayleigh beam coupled with a number of wave equations. All combinations of clamped and hinged boundary conditions with the control applied to either the moment or the rotation angle at an end of the Rayleigh beam are considered. One control is also applied for each wave equation. It is proved that exact controllability holds provided the damping parameters are sufficiently small. In the undamped case, exact controllability is shown to hold generically for almost every choice of parameters in the system. The standard multiplier technique with results from nonharmonic Fourier series due to Komornik and Haraux are combined to prove the results. (Received January 13, 2011)

1068-93-81 **K. N. Murty*** (nkanuri@hotmail.com), Yamnampet, Ghatkesar, Hyderabad 501 301, India. *Control of First-Order Matrix Sylvester system.*

In this talk, we shall be concerned with the first order non-homogeneous Sylvester system of the form

T'(t) = A(t)T(t) + T(t)B(t) + C(t)U(t)D*(t)

Y(t) = L1(t)T(t)L2*(t)

Where the matrices involved are of appropriate dimensions and are continuous on R, we address question related to input–output (zero state) behaviour of the linear system, and the minimum realization question of a specified transfer function. Under smoothness conditions we discuss controllability of the system and then present completely controllable and completely observable of the Sylvester System. We address questions related to minimal realization criteria in terms of controllability and observability. The results presented in this talk are more general and include the classical results as particular case. (Received January 13, 2011)

1068-93-89 **Qing Zheng*** (zheng003@gannon.edu), Gannon University, PMB 3236, 109 University Square, Erie, PA 16541. *An Active Disturbance Rejection Based Dynamic Decoupling Control Approach.*

In this paper, a unique dynamic decoupling control strategy, based on the active disturbance rejection control framework, is proposed for square multivariable systems. With the proposed method, it is shown that a largely unknown square multivariable system is readily decoupled by actively estimating and rejecting the effects of both the internal plant dynamics and external disturbances. By requiring as little information on plant model as possible, the intention is to make the new method practical. The stability analysis shows that both the estimation error and the closed-loop tracking error are bounded and the error upper bounds monotonously decrease with the bandwidths. Simulation results obtained on chemical process problems and micro-electro-mechanical systems show excellent performance in the presence of significant unknown disturbances and unmodeled dynamics. (Received January 14, 2011)

1068-93-91 **Jing Wang*** (wangj@cookman.edu), Department of Computer Engineering, Bethune-Cookman University, Daytona Beach, FL 32114. *Distributed Consensus Control for A Class of Nonholonomic Systems.*

In this paper, we propose a new distributed consensus control design for a class of networked dynamical systems with inherent nonlinear dynamics. A number of conditions are established in terms of the properties of the cooperative steering control for achieving cooperative behaviors. In particular, under assumptions that the considered individual nonlinear system is controllable and there exists a steering control in either feedback or open-loop form to move the system from one state to the other in finite time, the sampled-data cooperative steering control law can be designed based on the information received from the neighboring systems within the current sensor range. It is proved that the proposed cooperative steering control is cooperatively stabilizing if network is connected over time together with a mild condition imposed on sampling time. As an illustrative application case, cooperative steering control algorithms in closed form are presented to address the consensus problem of nonholonomic robot systems in chained form. Simulation results are provided to validate the proposed algorithms. (Received January 14, 2011)

1068-93-265 **David A Long**, **Anthony M Bloch**, **Jerrold E Marsden** and **Dmitry V Zenkov*** (dvzenkov@ncsu.edu). *Relaxed Method of Controlled Lagrangians.*

The method of controlled Lagrangians is a technique for feedback stabilization of relative equilibria of mechanical systems. The key step is to represent the controlled dynamics in the form of unforced Euler–Lagrange equations for a suitable new Lagrangian. The conditions for such a representation to exist are often very restrictive or even inconsistent. The suggested approach relaxes these conditions and is thus applicable to a larger class of mechanical systems. (Received January 19, 2011)

94 ► Information and communication, circuits

1068-94-85 **Akram Aldroubi** and **Xuemei Chen*** (xuemei.chen@vanderbilt.edu), 2513A W. Linden Ave., Nashville, TN 37212, and **Alexander Powell**. *Compressed sensing: Perturbations of the Measurement Matrices and the Dictionaries.*

The compressed sensing problem for redundant dictionaries aims to use a small number of linear measurements to represent signals that are sparse with respect to a general dictionary. Under an appropriate restricted isometry property for a dictionary, reconstruction methods based on ℓ^q minimization are known to provide an effective signal recovery tool in this setting. This note explores conditions under which ℓ^q minimization is robust to

measurement noise, and stable with respect to perturbations of the sensing matrix A and the dictionary D. We propose a new condition that guarantees that the ℓ^q minimization produces solutions that are robust and stable to perturbations of A and D and compressible signals – the D-null space property. We also show that ℓ^q minimization is jointly stable with respect to imprecise knowledge of the measurement matrix A and the dictionary D when A satisfies the restricted isometry property. (Received January 13, 2011)

1068-94-108 **Dale H. Mugler*** (dmugler@uakron.edu), Dept. of Biomedical Engineering, The University of Akron, Akron, OH 44325-1803. *Signal Cross-Correlation by Discrete, Dilated Hermite Functions.*

The continuous Hermite functions are eigenfunctions of the Fourier transform. In previous work, S. Clary and the author described an orthonormal set of eigenvectors for a *centered* version of the Fourier matrix that shares many of the properties of the continuous Hermite functions, and we called these eigenvectors the discrete Hermite functions. These eigenvectors can be easily computed as eigenvectors of a related tridiagonal matrix. Additionally, a dilation parameter can be introduced into that sparse matrix, whose eigenvectors create discrete, dilated Hermite functions. This talk concerns the properties of cross-correlation of vectors from this set of eigenvectors and how they can be applied to determine cross-correlations involving ultrawideband (UWB) signals. (Received January 15, 2011)

1068-94-155 **Armin Eftekhari**, **Justin Romberg** and **Michael B Wakin*** (mwakin@mines.edu). *Matched Filtering from Limited Frequency Samples.*

In the field of compressive sensing (CS) it is known that certain signals of high dimension but low complexity (namely, sparse signals) can be fully recovered from small numbers of random measurements. Similarly, certain low-complexity questions can be answered about possibly arbitrary signals directly from random measurements without first recovering the signal. In this talk, we discuss a simple correlation-based strategy for estimating the unknown delay and amplitude of a signal based on a small number of noisy, randomly chosen frequency-domain samples. We model the output of this "compressive matched filter" as a random process whose mean equals the scaled, shifted autocorrelation function of the template signal. Using tools from the theory of empirical processes—some of the same tools used for deriving signal recovery bounds in CS—we prove that the expected maximum deviation of this process from its mean decreases sharply as the number of measurements increases, and we also derive a probabilistic tail bound on the maximum deviation. Putting all of this together, we bound the minimum number of measurements required to guarantee that the empirical maximum of this random process occurs sufficiently close to the true peak of its mean function. (Received January 17, 2011)

1068-94-221 **Marco F Duarte**, **Michael B Wakin** and **Dror Baron*** (barondror@ncsu.edu), 2097 Engr Bldg II, NC State University, Raleigh, NC 27695, and **Shriram Sarvotham** and **Richard G Baraniuk**. *Ensemble Models for Multi-Signal Compressed Sensing.*

In compressed sensing, a small collection of linear projections of a sparse signal contain enough information for the signal to be recovered. Distributed compressed sensing (DCS) extends this framework to multi-signal problems, allowing an ensemble of signals to be jointly recovered from separately measured individual signals. This work introduces ensemble sparsity models for capturing intra- and inter-signal correlations within a multi-signal ensemble. For strictly sparse ensembles, we characterize the fundamental limits of DCS recovery when noiseless measurements are taken. Our analysis is based on a bipartite graph formulation that ties in sparse ensemble coefficients and the measurements. (Received January 18, 2011)

00 ► General

1069-00-250 **Ryan Martin** (rymartin@iastate.edu), 396 Carver Hall, Department of Mathematics, Iowa State University, Ames, IA 50011, and **Jason J Smith*** (smithj@iastate.edu), 396 Carver Hall, Department of Mathematics, Iowa State University, 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 H as a subgraph. The saturation number 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 a few specific graphs. (Received January 24, 2011)

01 ► History and biography

1069-01-49 **Michael O'Leary*** (oleary@cod.edu). *Archimedes and the Volume of a Sphere.*

Archimedes considered his proof of the formula for the volume of a sphere his greatest accomplishment. Due to the discovery of Heiberg in the early years of the twentieth century, we know a little more about the achievement of Archimedes than we do of much of ancient Greek mathematics. Using the *Method* and *On the Sphere and Cylinder*, this presentation will trace the Archimedean derivation of the formula beginning with his technique of balancing slices of volume on a lever to his geometric proof involving solid rhombi and volumes of revolution of regular polygons. (Received January 03, 2011)

1069-01-138 **Alexander F Kleiner*** (alexander.kleiner@drake.edu), Drake University, Mathematics and Computer Science, 2507 University Ave, Des Moines, IA 50311. *The Early History of Summability Theory Preliminary Report.* Preliminary report.

In the first two decades of the twentieth century summability developed from a collection of special results used in other parts of analysis into a full-blown field. One of the central events in this transition was a collection of general results that gave conditions for a method to sum every convergent sequence. This presentation will explore the background that led to the general theory, examine papers by Toeplitz, Silverman, Kojima, Schur that established the theory and, as time permits, further developments. (Received January 20, 2011)

1069-01-149 **Daniel J. Curtin*** (curtin@nku.edu), Northern Kentucky University, College of Arts and Ciences, SL 410, Highland Heights, KY 41075. *What numbers would Cardano use?* Preliminary report.

In his Ars Magna, and elsewhere, Girolamo Cardano generally seeks positive numerical solutions to problems whose constants and coefficients are also positive numbers. He does recognize the use of negative numbers in the process of solution, and in some cases recognizes possible negative solutions, which he calls false. He gives explanations of the meanings of these negative solutions that in some cases seem unusual to modern eyes. The use of negative numbers under a square root was forced on him in his solution of cubic equations and he gives some hesitant explanation of these, promising further details in the Regula Aliza. This talk is a preliminary study of these issues, intended to prepare a further careful study (and translation) of the Regula Aliza. (Received January 21, 2011)

1069-01-195 **Thomas Drucker*** (druckert@uww.edu), Dept. of Math. and Computer Sciences, University of Wisconsin–Whitewater, 800 West Main Street, Whitewater, WI 53190. *The Role of Languages in the Formulation of the Notion of an Ideal Language.* Preliminary report.

In Jeremy Gray's recent volume on modernism in mathematics, he devotes a section to artificial languages like Esperanto and Volapuk. The suggestion is that the creation of such languages was in line with the attitude of mathematicians in search of an ideal language to realize Leibniz's dream. Gray raises the question of how far the realization of the dream would guarantee that speakers would be unfailingly truthful and not just grammatical.

In this talk it will be argued that the motivation for universal languages can be connected with the aspect of Leibniz as diplomat, while the ideal language arose from his mathematical ideas. (Received January 23, 2011)

1069-01-213 **Lawrence A. D'Antonio*** (ldant@ramapo.edu), Ramapo College of New Jersey, Mahwah, NJ 07430. *Gauss and the Composition of Quadratic Forms.*

Gauss developed a magnificent theory of quadratic forms in his Disquisitiones Arithmeticae. What is the composition of forms and what role do they play in the Gauss's theory of quadratic forms? In this talk we will define the composition of quadratic forms as defined by Gauss, describe how quadratic forms are a group under composition and what Gauss knew about this, and discuss why Gauss needed to define the composition of forms. (Received January 24, 2011)

1069-01-346 **V. Frederick Rickey*** (fred.rickey@me.com), Department of Mathematical Sciences, USMA, West Point, NY 10996. *Logic in Warsaw, 1915–1939.* Preliminary report.

Stanisław Leśniewski (1886–1939) and Jan Łukasiewicz (1878–1956) joined the University of Warsaw faculty at the time that it was converted from a Russian language school to Polish. They were good teachers and were doing interesting research so a school started to form around them. A few years later they were joined by Alfred Tarski (1901-1983), who was Leśniewski's only Ph.D. student. Since Tarski immigrated to the US, his later work is well known, but the early work of the three is not so well known. After setting the scene, we will describe some of the work of Łukasiewicz on Aristotle's syllogistic and many-valued logics as well as the foundational system of Protothetic, Ontology, and Mereology, that Leśniewski developed from his own analysis of the Russell antinomy. (Received January 25, 2011)

05 ► Combinatorics

1069-05-01 **Mihai Ciucu*** (mciucu@indiana.edu), Rawles Hall, Bloomington, IN 47405. *Gaps in dimer systems and beyond.* Preliminary report.

The prototypical example of interaction of gaps in dimer coverings was formulated by Fisher and Stephenson in 1963. Suppose we have a huge $2n \times 2n$ chessboard, and we remove a white and a black unit square from around its center. How does the number of domino tilings of the leftover board change, as the two removed unit squares move around the center of the board?

We extend the set-up to dimer coverings on planar lattices, and focus on the interaction of a finite number of gaps in the dimer covering. A number of qualitatively different behaviors arise in this way. These include two-dimensional electrostatics, for bipartite lattices with critical weighting, and a radically different interaction for critical non-bipartite lattices. Effects of the boundary of lattice graphs will also be considered, as well as connections to some classical problems in enumerative combinatorics involving plane partitions and spanning trees.

Throughout the discussion there is a helpful interplay between combinatorics and physical intuition. The talk is intended for a general audience. (Received January 25, 2011)

1069-05-11 **Zhongyang Li*** (Zhongyang_Li@brown.edu), Providence, RI 02912. *Local Statistics of Realizable Vertex Models.*

We study planar "vertex" models, which are probability measures on edge subsets of a planar graph, satisfying certain constraints at each vertex, examples include dimer model, and 1-2 model, which we will define. A generalized holographic algorithm is applied to reduce the vertex model problem to counting perfect matchings, and conditions under which the vertex model problem can be realized (reduced holographically) to a planar dimer model are discussed. For finite graphs, we express the local statistics of the realizable vertex model as a linear combination of the local statistics of dimers. Using an $n \times n$ torus to approximate the periodic infinite graph, we study the asymptotic behavior of the free energy and local statistics of realizable vertex models. The convergence rate of covariance of local configurations is determined when the distance between the two vertices goes to infinity. As an example, we simulate the 1-2 model using the technique of Glauber dynamics. (Received November 07, 2010)

1069-05-21 **Marius Somodi*** (somodi@uni.edu), Department of Mathematics, University of Northern Iowa, Cedar Falls, IA 50614, and **Paymun Bayati**, Department of Mathematics, University of Northern Iowa, Cedar Falls, IA 50614. *Zeta function of cones over regular graphs.*

We present a formula of the Ihara zeta function of a cone over a regular graph that involves the spectrum of the adjacency matrix of the cone. Using this formula we characterize the cones that satisfy the graph

theory Riemann hypothesis and identify properties of the cone that can be determined using the zeta function. (Received November 24, 2010)

1069-05-22 **Fusun Akman*** (akmanf@ilstu.edu), Normal, IL 61790-4520, and **Papa A Sissokho** (psissok@ilstu.edu), Normal, IL 61790-4520. *Types of finite vector space partitions.* Preliminary report.

Let $V = V(n, q)$ denote the finite vector space of dimension n over the finite field with q elements. A *subspace partition* of V is a collection Π of subspaces of V such that each 1-dimensional subspace of V is in exactly one subspace of Π. In a recent paper, we proved some strong connections between the lattice of the subspace partitions of V and the lattice of the set partitions of $S = \{1, \ldots, n\}$.

The *type* of a subspace partition is the multiset of dimensions of the subspaces making up the partition and is analogous to an *integer partition* of n. In this talk we will discuss the types of all subspace partitions of V in relation to the integer partitions of n and present some insightful examples to illustrate this relationship. (Received November 24, 2010)

1069-05-45 **Bruce Sagan*** (sagan@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824, and **Carla Savage** (savage@cayley.csc.ncsu.edu), Department of Computer Science, North Carolina State University, Raleigh, NC 27695. *Mahonian Pairs.* Preliminary report.

We introduce the notion of a Mahonian pair. Consider the set, $\mathbb{P}^*$, of all words having the positive integers as alphabet. Given finite subsets $S, T \subset \mathbb{P}^*$, we say that (S, T) is a *Mahonian pair* if the distribution of the major index, maj, over S is the same as the distribution of the inversion number, inv, over T. So the well-known fact that maj and inv are equidistributed over the symmetric group, $\mathfrak{S}_n$, can be expressed by saying that $(\mathfrak{S}_n, \mathfrak{S}_n)$ is a Mahonian pair. We investigate various Mahonian pairs (S, T) with $S \neq T$. Our principal tool is Foata's fundamental bijection $\phi : \mathbb{P}^* \to \mathbb{P}^*$ since it has the property that $\operatorname{maj} w = \operatorname{inv} \phi(w)$ for any word w. We consider various families of words associate with Catalan and Fibonacci numbers. Various other ideas come into play such as the ranks and Durfee square size of integer partitions, the Catalan triangle, and various q-analogues.

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1069-05-46 **Derrick Stolee*** (s-dstolee1@math.unl.edu), Lincoln, NE 68588-0130. *Isomorph-free generation of 2-connected graphs with applications.* Preliminary report.

In this work we discuss generating 2-connected graphs through ear augmentations, generating a single copy of each isomorphism class through the use of canonical deletion. This is primarily used for two applications where the structure given by the ear augmentations is central to solving the given problem. The first application verifies the edge reconstruction conjecture over sparse 2-connected graphs. The second application generates structural characterizations for extremal graphs with exactly p perfect matchings, where p is a small constant. (Received December 21, 2010)

1069-05-54 **Radoslav Fulek**, **Michael J Pelsmajer*** (pelsmajer@iit.edu), **Marcus Schaefer** and **Daniel Stefankovic**. *Strong Hanani-Tutte for x-monotone graphs.*

A curve in the plane is *x-monotone* if it intersects every vertical line at most once. Pach and Toth showed that if a graph G can be drawn so that all its edges are x-monotone and every pair of edges crosses an even number of times, then G has a crossing-free straight-line drawing in which the x-coordinates of all vertices are unchanged.

We strengthen this result by showing that the same conclusion remains true even if we allow pairs of edges to cross oddly, as long as any two oddly-crossing edges have a common endpoint. This answers a question posed by Pach and Toth. (Received January 06, 2011)

1069-05-55 **Alexandr Kostochka*** (kostochk@math.uiuc.edu), Department of Mathematics, 1409 W. Green St., Urbana, IL 61801. *On a class of color-critical graphs and hypergraphs.* Preliminary report.

Recall that a (hyper)graph is *d-degenerate* if every of its nonempty subgraphs has a vertex of degree at most d. Every d-degenerate (hyper)graph is (easily) $(d+1)$-colorable. A (hyper)graph is *almost d-degenerate* if it is not d-degenerate, but every its proper subgraph is d-degenerate. In particular, if G is almost $(k-1)$-degenerate, then after deleting any edge it is k-colorable. Let $\mathcal{F}_k$ (respectively, $\widetilde{\mathcal{F}}_k$) denote the set of almost $(k-1)$-degenerate graphs (respectively, hypergraphs) that are not k-colorable. By definition, each hypergraph in $\widetilde{\mathcal{F}}_k$ is $(k+1)$-critical. In 1975, Borodin asked to describe the graphs in $\mathcal{F}_k$. We give some description of hypergraphs in $\widetilde{\mathcal{F}}_k$ for $k = 2$ and $k \geq 4$. (Received January 07, 2011)

1069-05-66 **Andrew Beveridge*** (abeverid@macalester.edu), Department of Mathematics, Macalester College, 1600 Grand Avenue, Saint Paul, MN 55105, and **Jorge Banuelos** (jbanuelo@macalester.edu), Department of Mathematics, Macalester College, 1600 Grand Avenue, Saint Paul, MN 55105. *A Simultaneous Random Walk Game.*

Two tokens are placed on vertices of a graph. At each time step, one token is chosen and is moved to a random neighboring vertex. In previous work, Tetali and Winkler studied the Angel strategy for bringing the tokens together as quickly as possible (in expectation), and the Demon strategy for delaying their collision as long as possible. We build on these results by studying a game version of this process. In our game, two players take turns choosing the token to move. The Angel player hopes to bring the tokens together while the Demon player tries to keep them apart. We present optimal strategies for both players on some families of graphs, including cycles, paths and m-ary trees. Our proofs employ couplings of random walks as well as strategy stealing arguments. (Received January 11, 2011)

1069-05-68 **David Galvin*** (dgalvin1@nd.edu), Department of Mathematics, University of Notre Dame, Notre Dame, IN. *Unimodality of the independent set sequence of a graph.*

For a graph G, let $i_t(G)$ denote the number of independent sets (stable sets) of size t, that is, the number of subsets of size t of the vertex set whose elements are pairwise non-adjacent.

Heilmann and Lieb (1972) showed that if G is a line graph, then the independent set sequence $(i_t(G))_{t\geq 1}$ is unimodal. Chudnovsky and Seymour (2007) extended this, showing that the independent set sequence of any claw-free graph is unimodal. In the general case, however, there is no constraint on the locations of the maxima and minima of the independent set sequence; this was shown by Alavi, Erdős, Malde and Schwenk (1987).

Alavi et al. made the conjecture that if G is a tree then the independent set sequence is unimodal, and Levit and Mandrescu (2006) have made the stronger conjecture that being bipartite is sufficient for unimodality. Very little progress has been made on either of these conjectures.

In this talk I'll discuss what is known. Among other things, I'll show that Levit and Mandrescu's conjecture is almost surely true: with high probability, the random equibipartite graph has unimodal independent set sequence. (Received January 12, 2011)

1069-05-73 **John R Stembridge*** (jrs@umich.edu). *A finiteness theorem for W-graphs.* Preliminary report.

Let W be a finite Coxeter group. A W-graph is a combinatorial structure that encodes a W-module, or more generally, a module for the associated Iwahori-Hecke algebra. Of special interest are the W-graphs that encode the action of the Hecke algebra on its Kazhdan-Lusztig basis, as well as the action on individual cells. Knowing the W-graph allows easy computation of the Kazhdan-Lusztig polynomials.

One may isolate a few elementary features common to the W-graphs in Kazhdan-Lusztig theory and use these to define a class of "admissible" W-graphs. In this talk, we will explain a surprisingly simple (but non-constructive) proof that there are only finitely many admissible W-cells (i.e., strongly connected W-graphs). (Received January 13, 2011)

1069-05-79 **Christian Krattenthaler*** (Christian.Krattenthaler@univie.ac.at), Fakultät für Mathematik, Universität Wien, Nordbergstraße 15, A-1090 Vienna, Austria, and **Thomas W. Müller**. *Cyclic sieving for generalised non-crossing partitions associated to complex reflection groups.*

Cyclic sieving is a(n enumerative) phenomenon formulated by Reiner, Stanton and White. Bessis and Reiner proposed two conjectures on cyclic sieving phenomena for the generalised non-crossing partitions associated to complex reflection groups of Armstrong and Bessis. I shall sketch a (case-by-case) proof of these conjectures. Part of this work is in collaboration with Thomas Müller. (Received January 14, 2011)

1069-05-91 **John Lenz*** (jlenz2@math.uiuc.edu) and **Jozsef Balogh**. *On the Ramsey-Turán Numbers of Graphs and Hypergraphs.*

Let t be an integer, $f(n)$ a function, and H a graph. Define the t-Ramsey-Turán number of H, $RT_t(n, H, f(n))$, to be the maximum number of edges in an n-vertex, H-free graph G with $\alpha_t(G) \leq f(n)$, where $\alpha_t(G)$ is the maximum number of vertices in a K_t-free induced subgraph of G. In 1994, Erdős, Hajnal, Simonovits, Sós, and Szemerédi posed several open questions about $RT_t(n, K_s, o(n))$, among them finding the minimum ℓ such that $RT_t(n, K_{t+\ell}, o(n)) = \Omega(n^2)$. We answer this question by proving that $RT_t(n, K_{t+2}, o(n)) = \Omega(n^2)$. From the other side, it is easy to see that $RT_t(n, K_{t+1}, o(n)) = o(n^2)$. Our constructions which show that $RT_t(n, K_{t+2}, o(n)) = \Omega(n^2)$ also imply several results on the Ramsey-Turán numbers of hypergraphs. (Received January 16, 2011)

1069-05-97 **Suil O**, **Douglas B. West** and **Hehui Wu*** (hehuiwu2@illinois.edu), Department of Mathematics, University of Illinois, Urbana, IL 61801. *Longest cycles in graphs with given independence number and connectivity.*

The Chvátal–Erdős Theorem states that every graph whose connectivity is at least its independence number has a spanning cycle. In 1976, Fouquet and Jolivet conjectured an extension: If G is an n-vertex k-connected graph with independence number a, and $a \geq k$, then G has a cycle with length at least $\frac{k(n+a-k)}{a}$. We prove this conjecture. (Received January 17, 2011)

1069-05-99 **Mirjana Vuletić*** (Mirjana_Vuletic@brown.edu). *Plane overpartitions and cylindric partitions.*

Generating functions for plane overpartitions are obtained using various methods such as nonintersecting paths, RSK type algorithms and symmetric functions. We extend some of the generating functions to cylindric partitions. Also, we show that plane overpartitions correspond to certain domino tilings and we give some basic properties of this correspondence. This is a joint work with Sylvie Corteel and Cyrille Savelief. (Received January 17, 2011)

1069-05-109 **Jonathan Cutler** (jonathan.cutler@montclair.edu) and **Andrew J Radcliffe*** (aradcliffe1@math.unl.edu). *Counting homomorphisms.*

There has been a variety of recent work on extremal problems for the enumeration of homomorphisms. For instance Kahn proved that among all d-regular bipartite graphs those with the largest number of independent sets were disjoint unions of copies of $K_{d,d}$. (An independent set can be regarded as a homomorphism into a particular two vertex graph with a loop.) I will discuss various such results, including recent work with Jonathan Cutler on the graph having n vertices, e edges, and the fewest independent sets. (Received January 18, 2011)

1069-05-119 **Adam Jobson** and **Andre Kezdy*** (kezdy@louisville.edu), Natural Sciences Building, Room 328, Department of Mathematics, University of Louisville, Louisville, KY 40292, and **Hunter Snevily** and **Susan C. White**. *Ramsey Functions for Quasi-Progressions with Large Diameter.*

A k-term quasi-progression of diameter d is a sequence

$$x_1 < \cdots < x_k$$

of positive integers for which there exists a positive integer l such that $l \leq x_j - x_{j-1} \leq l + d$, for all $j = 2, \ldots, k$. Let $Q(d, k)$ be the least positive integer such that every 2-coloring of $\{1, \ldots, Q(d, k)\}$ contains a monochromatic k-term quasi-progression of diameter d. We prove that

$$Q(k - i, k) = 2ik - 4i + 2r - 1,$$

if $k = mi + r$ for integers m, r such that $3 \leq r < \frac{i}{2}$ and $r - 1 \leq m$. We also prove that, if $k \geq 2i \geq 1$, then

$$Q(k - i, k) = \begin{cases} 2ik - 4i + 3 & \text{if } k \equiv 0 \text{ or } 2 \pmod{i} \\ 2ik - 2i + 1 & \text{if } k \equiv 1 \pmod{i} \end{cases}$$

These results partially settle several conjectures due to Landman [Ramsey Functions for Quasi-Progressions, Graphs and Combinatorics 14 (1998) 131-142]. (Received January 19, 2011)

1069-05-120 **Alexander Yong***, Dept of Math, U. Illinois at Urbana-Champaign, Urbana, IL 61801. *Gröbner bases and singularities of Schubert varieties.*

Gröbner bases are applied to study discrete invariants of singularities of Schubert varieties, such as Hilbert-Samuel multiplicity and Kazhdan-Lusztig polynomials. I will discuss work with Li Li (Oakland University) and with Alexander Woo (St. Olaf College). (Received January 19, 2011)

1069-05-121 **Michelle A. Lastrina*** (lastrina@iastate.edu). *List-coloring planar graphs from lists of different sizes.* Preliminary report.

A famous theorem of Thomassen states that no matter how lists of five colors are assigned to the vertices of a planar graph, there is always a way to choose a color for each vertex from its list so that the resulting coloring is proper. Here we explore the conjecture that if some of the lists are smaller, specifically two vertices on the unbounded face are assigned lists of two colors and the remaining vertices on the unbounded face are assigned lists of three colors, then there is always a way to properly color the graph so that the color assigned to each vertex comes from its corresponding list. We present some classes of graphs for which such a coloring exists. (Received January 19, 2011)

1069-05-145 **Younjin Kim*** (ykim36@illinois.edu), Mathematics Dept., University of Illinois, Urbana, IL 61801, and **Zoltan Furedi**. *Cycle-saturated graphs with minimum number of edges.*

A graph G is called F-saturated if it does not contain any copy of F, but for any edge e in the complement of G the graph $G+e$ contains some F. The minimum size of an n-vertex F-saturated graph is denoted by $sat(n,F)$. We give almost exact asymptotics for $sat(n,C_k)$ as k is fixed and $n\to\infty$ where C_k is a cycle with length k. This is a joint work with Zoltán Füredi. (Received January 21, 2011)

1069-05-155 **Yair Caro** and **Douglas B. West*** (west@math.uiuc.edu), Mathematics Dept., University of Illinois, 1409 W. Green Street, Urbana, IL 61801, and **Raphael Yuster**. *Equitable orientations of hypergraphs.*

An *orientation* of a hypergraph chooses for each edge a linear ordering of its vertices. For $1\le p<r$, an orientation of an r-uniform hypergraph is *p-equitable* if each p-set of vertices occupies each p-set of positions in about the same number of edges. We prove that every r-uniform hypergraph has 1-equitable and $(r-1)$-equitable orientations. The special case $r=2$ (graphs) is well known, stating that some orientation has indegree and outdegree differing by at most 1 at each vertex. For $1<p<r-1$, we prove a necessary condition, implying that some complete r-uniform hypergraphs have no p-equitable orientation. We conjecture that when p and k are fixed and each p-set of vertices appears in at most k edges, p-equitable orientations always exist when r is sufficiently large. We use the Local Lemma to prove that large enough r ensures an orientation that is "nearly" p-equitable, with each p-set of vertices occupying each p-set of positions at most twice. (Received January 21, 2011)

1069-05-156 **Michael Young*** (myoung@iastate.edu) and **James Cummings**. *Graphs containing triangles are not 3-common.*

A graph G is k-common ($k\ge 1$) if the minimum number of monochromatic copies of G over all k edge colorings of K_n is asymptopic to the expected number of monochromatic copies of G in a random k edge coloring. Jagger, Šťovíček and Thomason defined the class of *k-common* graphs, and showed among other results that every graph containing K_4 as a subgraph is not 2-common. We prove that every graph containing K_3 as a subgraph is not 3-common. (Received January 21, 2011)

1069-05-181 **Andrew Berget***, University of California, Department of Mathematics, Davis, CA 95616, and **Alexander Fink**, North Carolina State University, Department of Mathematics, Raleigh, NC 27695. *Cohomology classes of torus orbit closures in Grassmannians.* Preliminary report.

Given a point x in a Grassmannian, the cohomology class $[\overline{xT}]$ of the torus orbit closure through x is known to depend only on which Plücker coordinates of x are non-zero. This is to say, $[\overline{xT}]$ depends only on the matroid of x. I will explain a few aspects of how the matroid of x can be seen in the Schubert decomposition of $[\overline{xT}]$. In particular, I will present a formula for these multiplicities when x is a 2-dimensional subspace, or a sufficiently general r-dimensional subspace. This is joint work with Alex Fink. (Received January 22, 2011)

1069-05-192 **J. Haglund*** (jhaglund@math.upenn.edu), Math Dept., UPenn, 209 S. 33rd St., Philadelphia, PA 19104-. *Macdonald polynomials and the Hilbert series of the space of diagonal coinvariants.*

We discuss a result of the speaker, which gives a polynomial expression for the Hilbert series of the space of diagonal coinvariants in terms of certain types of matrices. The proof uses a summation formula for Macdonald Pieri coefficients due to Garsia and Zabrocki. We also discuss some related conjectures involving constant terms in multivariate Laurent series. (Received January 23, 2011)

1069-05-193 **Aba Mbirika*** (ambirika@bowdoin.edu). *Commutative algebra meets geometric representation theory.*

The well-studied Springer variety is at the center 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 use techniques of 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 January 24, 2011)

1069-05-211 **Bela Csaba*** (bela.csaba@wku.edu), **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 January 24, 2011)

1069-05-216 **Robert G. Donnelly*** (rob.donnelly@murraystate.edu), Department of Mathematics and Statistics, 6C Faculty Hall, Murray State University, Murray, KY 42071. *Poset models for irreducible Weyl characters.*

Irreducible Weyl characters are natural generalizations of Schur functions from symmetric function theory. In this general setting, the underlying symmetry group is a Weyl group. A "splitting poset" for an irreducible Weyl character is an edge-colored ranked poset possessing a certain structural property and a natural weighting of its elements so that the weighted sum of poset elements is the given Weyl character. Connected such posets are rank symmetric and rank unimodal and have nice quotient-of-product expressions for their rank generating functions. Supporting graphs, Kashiwara's crystal graphs, Littelmann's path model, and Stembridge's admissible systems provide examples of such posets arising in Lie theory. A cancelling argument of Stembridge is reworked to provide sufficient combinatorial conditions for a given poset to be splitting. In a companion result, Gansner's symmetric chain decomposition of chain products by parenthesization is used to establish a different set of sufficient conditions. These results are applied to demonstrate that certain distributive lattices are splitting posets for the irreducible Weyl characters corresponding to simple Lie algebra representations whose highest weights are combinations of minuscule or other special fundamental weights. (Received January 24, 2011)

1069-05-239 **Zoltan Furedi** and **Lale Ozkahya*** (ozkahya@iastate.edu). *Unavoidable subhypergraphs:* **a**-*clusters.*

One of the central problems of extremal hypergraph theory is the description of unavoidable subhypergraphs, in other words, the Turán problem. Let $\mathbf{a} = (a_1, \ldots, a_p)$ be a sequence of positive integers, $k = a_1 + \cdots + a_p$. An **a**-*partition* of a k-set F is a partition in the form $F = A_1 \cup \ldots A_p$ with $|A_i| = a_i$ for $1 \leq i \leq p$. An **a**-*cluster* $\mathcal{A}$ with *host* F_0 is a family of k-sets $\{F_0, \ldots, F_p\}$ such that for some **a**-partition of F_0, $F_0 \cap F_i = F_0 \setminus A_i$ for $1 \leq i \leq p$ and the sets $F_i \setminus F_0$ are pairwise disjoint. The family $\mathcal{A}$ has $2k$ vertices and it is unique up to isomorphisms. With an intensive use of the delta-system method we prove that for $k > p$ and sufficiently large n, if $\mathcal{F}$ is a k-uniform family on n vertices with $|\mathcal{F}|$ exceeding the Erdős-Ko-Rado bound $\binom{n-1}{k-1}$, then $\mathcal{F}$ contains an **a**-cluster. The only extremal family consists of all the k-subsets containing a given element. (Received January 24, 2011)

1069-05-258 **Oscar Vega*** (ovega@csufresno.edu), 5245 North Backer Avenue M/S PB 108, Fresno, CA 93730, and **Larry Cusick** (larryc@csufresno.edu), 5245 North Backer Avenue M/S PB 108, Fresno, CA 93730. *Groups of derangements of the n-cube.*

A group G of derangement of the k-faces of the n-cube Q_n is a group that acts on Q_n in such a way that the only element in G fixing any k-face is the identity. A classification of these groups was given by Chen and Stanley in 1993, and since then not much has been done to understand these groups.

Recently, we have proved that given a positive integer k and a group G such that $\gcd(|G|, k) = 2^s$ for some s, then there is an integer n such that G is a derangement of the k-faces of Q_n. This talk will feature the ideas used to prove this result. (Received January 24, 2011)

1069-05-259 **Richard W. Kenyon** and **David B. Wilson***, One Microsoft Way 99/2928, Redmond, WA 98052. *Double-dimer pairings and skew Young diagrams.*

We study the number of tilings of skew Young diagrams by ribbon tiles shaped like Dyck paths, in which the tiles are "vertically decreasing". We use these quantities to compute pairing probabilities in the double-dimer model: Given a planar bipartite graph G with special vertices, called nodes, on the outer face, the double-dimer model is formed by the superposition of a uniformly random dimer configuration (perfect matching) of G together with a random dimer configuration of the graph formed from G by deleting the nodes. The double-dimer configuration consists of loops, doubled edges, and chains that start and end at the boundary nodes. We are interested in how the chains connect the nodes. An interesting special case is when the graph is $\varepsilon(\mathbb{Z} \times \mathbb{N})$ and the nodes are at evenly spaced locations on the boundary $\mathbb{R}$ as the grid spacing $\varepsilon \to 0$. (Received January 24, 2011)

1069-05-264 **Robert A. Proctor*** (rap@email.unc.edu), Department of Mathematics, University of North Carolina, Chapel Hill, NC 27599-3250. *Two Denominator Formulas for Each Element of a Kac-Moody Weyl Group.* Preliminary report.

Divide the shifted denominator identity for any Kac-Moody algebra into 1. This inverted identity is reinterpreted and generalized. For every element w in the Weyl group of the algebra, we present product formulas for the

limits of families of "up" and "down" Demazure formal characters (of Borel subalgebras) that are associated to w. The two products are each indexed by sets of roots. When w = e, the "down" formula is the inverted shifted denominator product identity for the algebra. This product is over all negative roots; it is the expression for the generating function for the Kostant partition function. The "up" formula was created by D. Peterson in 1997 in an algebraic geometric context for the proof of this author's then-conjectural hook product identity for P-partitions on d-complete posets. This "up" formula (for any w) is obtained by forming an analogous product over the roots that are flipped to positive by w. For the d-complete proof, the "up" formulas were needed only for the lambda-minuscule w's in the simply-laced cases. Although the general "up" identity was also known to S. Kumar in the algebraic geometric context by 1996, as A. Berenstein noted in 2009 only elementary representation theory constructions are actually needed for its proof. (Received January 24, 2011)

1069-05-266 **Lindsay Anne Erickson*** (lindsay.merchant@ndsu.edu) and **Warren Shreve**. *Nim on hypercubes.*

The two-player game of Nim on graphs is played on a regular graph with positively weighted edges by moving alternately from a fixed starting vertex to an adjacent vertex, decreasing the weight of the incident edge to a strictly smaller non-negative integer. The game ends when a player is unable to move since all edges incident with the vertex from which the player is to move have weight zero. In this paper, we consider the winning strategy for the hypercubes with unit weight. A special winning strategy is described for the players, and we provide a proof of the theorem showing that the winner of hypercubes depends on the parity of the vertex. Furthermore, we give a survey on hypercubes with arbitrary weight. (Received January 24, 2011)

1069-05-279 **Angela Angeleska*** (aangeleska@ut.edu), 401 W. Kennedy Blvd., Tampa, FL 33606, and **Natasha Jonoska**, **Masahiko Saito** and **Laura Landweber**. *Pathways for DNA rearrangement in ciliates.*

We study the order of DNA recombination events that take place in some species of ciliates. The recombination processes happen in certain succession, possibly with some recombination events performed at the same time, but others in prescribed order. We model this cascade process by defining partial order on DNA molecules in such a way that two molecules are related by the order when one is produced by rearrangement from the other. Our model is applied to recently obtained experimental data of possible intermediate molecules in the gene assembly. The intermediates are used to derive all possible pathways for DNA rearrangement. (Received January 24, 2011)

1069-05-282 **Georgia Benkart*** (benkart@math.wisc.edu), Department of Mathematics, University of Wisconsin-Madison, 480 Lincoln Dr., Madison, WI 53706, and **Dongho Moon** (dhmoon@sejong.ac.kr), Department of Applied Mathematics, Sejong University, 98 Kunja-dong, Kwangjin-gu, Seoul, 143-747, South Korea. *Centralizer Algebras and Pattern-Avoiding Permutations.* Preliminary report.

The centralizer algebra of a representation (the algebra of transformations commuting with the representing transformations) plays a useful role in decomposing the space. In many important examples, the centralizer algebra has a nice basis of diagrams. Here we will discuss some examples where the basis can be described using pattern avoiding permutations. (Received January 24, 2011)

1069-05-287 **Carmen Caprau*** (ccaprau@csufresno.edu), Department of Mathematics, 5245 N. Backer Avenue M/S PB 108, Fresno, CA 93740, and **James Tipton**. *A polynomial invariant of 3-valent graphs embedded in the three dimensional space.* Preliminary report.

We construct a polynomial invariant of rigid vertex isotopy for 3-valent graphs embedded in the three dimensional space, via the skein formalism approach to knot theory and a graphical calculus that assigns well-defined polynomials to planar 3-valent graphs.

We also show that our construction provides a representation of braid groups into some algebra given by generators and relations. (Received January 25, 2011)

1069-05-299 **Csaba Biro*** (csaba.biro@louisville.edu). *Clique number of graphs with high chromatic number.*

We study graphs whose chromatic number is close to the order of the graph. Both when the chromatic number is a constant multiple of the order and when the difference of the chromatic number and the order is a small fixed number, large cliques are forced. We study the latter situation, pose a conjecture about the forced size of the largest clique, and prove it for some special cases. (Received January 25, 2011)

1069-05-300 **Timothy Y Chow*** (tchow@alum.mit.edu). *Recent progress on Rota's basis conjecture.* Let V be a vector space of dimension n, and let $B_1, B_2, \ldots, B_n$ be n bases of V, not necessarily distinct or disjoint. Rota conjectured in 1989 that there must exist an $n \times n$ grid of vectors whose ith row comprises the elements of B_i and whose columns are all bases of V. Rota's conjecture remains open but there has been substantial partial progress from several different directions in the last few years. We will give a survey of these results. (Received January 25, 2011)

1069-05-303 **Hung Yu Chang*** (hychang@crimson.ua.edu), 308 15th Street East, Tuscaloosa, AL 35401. *Non-geometric Brownian motion model estimated by Markov Chain approximation.* The complex structure of a non-geometric Brownian motion model has increased the difficulty in obtaining analytical expressions. According, we apply time-homogeneous Markov Chain method to measure the price of a modified barrier option, which underlying asset is constructed by a non-geometric Brownian motion. The discretely monitored measurement is based constant and time-dependent volatility in equally partitioned time interval. The price of the modified barrier option is generated by the power p of the underlying asset. We investigate the range of the power p in order to achieve an optimal portfolio of financial investments.
Note: we consider a non-geometric Brownian motion (NGBM) $dS_t = S_t^p(\mu_t dt + \sigma_t dW_t)$, where S_t^p is a time-dependent random variable raised to a constant power $p = (p \in \mathbf{R}^+ \backslash \{0, 1\})$, μ_t and σ_t, the drift and the volatility, are adapted processes, W_t is a standard Brownian motion where $W_0 = 0$. (Received January 25, 2011)

1069-05-316 **Kevin Purbhoo***, Combinatorics & Optimization Department, University of Waterloo, Waterloo, ON , Canada, and **Allen Knutson**. *Puzzle and product formulae for GL(n) Belkale-Kumar coefficients.* The Belkale-Kumar product is a degeneration of the standard cup product on a generalized flag variety, which is turns out to be more relevant for eigenvalue problems than the ordinary cup product. I will discuss a puzzle rule for the Belkale-Kumar product on cohomology of partial flag varieties (in type A). The rule comes from a factorization theorem certain Schubert intersection numbers. This is joint work with Allen Knutson. (Received January 25, 2011)

1069-05-323 **Hemanshu Kaul*** (kaul@iit.edu), 10 W 32 St., Dept.. of Mathematics, Illinois Institute of Tech, Chicago, IL 60616. *Graph Packing and Degree Sequences.* Two graphs G_1 and G_2 are said to pack if there exists a simple graph that contains edge-disjoint copies of G_1 and G_2. Two families of graphs $\mathcal{G}_1$ and $\mathcal{G}_2$ are said to pack if there exist $G_i \in \mathcal{G}_i$ such that G_1 and G_2 pack.

In this talk we will present results on packing of families of graphs that consist of all possible realizations of degree sequences. We have the additional requirement that, unlike the usual graph packing, the vertices can not be permuted to allow packing. Given degree sequences π_1 and π_2, the degree sequence packing problem is to determine if there exist edge-disjoint graphs G_1 and G_2 on the same vertex set such that G_i has degree sequence π_i.

We will present Sauer-Spencer type degree conditions for packing degree sequences, and some extensions of Kundu's classical k-factor theorem on packing of a graphic sequence with an almost k-regular degree sequence. This is joint work with A.H. Busch, M.J. Ferrara, S.G. Hartke, M.S. Jacobson, and D.B. West. (Received January 25, 2011)

1069-05-325 **Andrew J Radcliffe** (aradcliffe1@math.unl.edu) and **Andrew B Ray*** (ray.andrew@gmail.com), University of Nebraska-Lincoln, Department of Mathematics, 315 Avery Hall, Lincoln, NE 68588. *Extremal Trees with Given Degree Sequence.* Preliminary report.
We solve the question of which tree with a given degree sequence has the largest number of independent sets. The solution turns out to be the *festoon* with that degree sequence. We will define the festoon and compare it to the *ball* with that degree sequence. The ball has previously been shown to maximize the spectral radius and minimize the Wiener index. We show that the ball maximizes the number of subtrees. (Received January 25, 2011)

1069-05-326 **Zoltan Furedi*** (z-furedi@illinois.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W Green Street, Champaign, IL 61801. *2-cancellative uniform hypergraphs.* Preliminary report.
A family $\mathcal{F}$ of sets is called 2-cancellative if for any four distinct members $A, B, C, D \in \mathcal{F}$

$$A \cup B \cup C \neq A \cup B \cup D.$$

We consider $M(n,k)$, the size of the largest 2-cancellative k-uniform family on n vertices, thus answering a question of G. O. H. Katona. Many problems remain open.

This is in fact, a Turán type problem, and has many connections to other well-known questions like the Ruzsa-Szemerédi $(6,3)$-theorem. The constructions (of the almost) optimal hypergraphs are algebraic. (Received January 25, 2011)

1069-05-333 **Alexander Postnikov*** (apost@math.mit.edu), MIT, Dept. Math, 77 Massachusetts Ave, Cambridge, MA 02139. *Positroids, polytopes, and quantum minors.*

Positroids and plabic graphs appeared in the study of total positivity on the Grassmannian. We discuss how these combinatorial objects show up in several different contexts. We mention an interesting class of convex polytopes related to these objects. (Based on a joint work with Thomas Lam.) We also describe a correspondence between plabic graphs and weakly separated collections from Leclerc-Zelevinsky's work on quasi-commuting families of minors. In particular, this correspondence implies their purity conjecture. (Based on a joint work with David Speyer and Suho Oh.) (Received January 25, 2011)

1069-05-349 **Stephen G. Hartke*** (hartke@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588-0130, and **Tyler Seacrest** (s-tseacre1@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588-0130. *Finding many edge-disjoint 1-factors in dense graphs.* Preliminary report.

Motivated by a conjecture of Busch, Ferrara, Hartke, Jacobson, Kaul, and West, we search for many edge-disjoint 1-factors in dense graphs. We will discuss partial results on this question, including probabilistic approaches and a potential version: for any degree sequence π of length n with minimum at least $n/2$, we show that there exists a realization G of π with many edge-disjoint 1-factors. (Received January 25, 2011)

1069-05-350 **Anders S. Buch*** (asbuch@math.rutgers.edu) and **Matthew Samuel**. *K-theory of minuscule varieties.* Preliminary report.

Thomas and Yong have conjectured a Littlewood-Richardson rule for the K-theory of any minuscule homogeneous space, based on their K-theoretic jeu de taquin algorithm. This conjecture has been proved for Grassmannians of type A and maximal orthogonal Grassmannians, but it fails for the Freudenthal variety of type E_7. I will speak about a fix that replaces superstandard tableaux with minimal increasing tableaux as the rectification targets. Other advantages of minimal increasing tableaux include that they make it easier to recognize which tableaux to count, and their antirectifications can be described explicitly. We also prove that arbitrary tableaux can be used as rectification targets, provided that only the greedy rectification order is allowed. (Received January 25, 2011)

06 ► Order, lattices, ordered algebraic structures

1069-06-29 **Roger D. Maddux*** (maddux@iastate.edu), Math Dept, 396 Carver Hall, ISU, Ames, IA 50011. *Do all the Ramsey algebras exist?* Preliminary report.

A "Ramsey algebra" may be described as a representation of a finite symmetric integral relation algebra with all 2-cycles and all 3-cycles but no 1-cycles. Alternatively, a Ramsey algebra is a coloring of the edges of K_n (the complete graph on n points) with k colors so that there are no monochromatic triangles, the composition of two distinct colors (as binary relations) is the diversity relation on n points, and the composition of a color with itself is the union of identity relation on n points with all the other colors. Ramsey algebras were shown to exist for some small values of k by Comer in 1983, and were later allegedly proved to exist for all sufficiently large k by Erdös, Szemeredi, and Trotter. This talk will describe these two approaches and report on recent progress. (Received December 01, 2010)

1069-06-44 **Elijah James Stines*** (ejstines@iastate.edu). *Abelian Quasi Ordered Groups.*

In this talk we shall discuss results concerning the category **QAb** of abelian quasi ordered groups with order preserving morphisms. Specifically, we shall construct an isomorphic category and an adjunction with the category $\mathbf{Set}^m$, the category of set monomorphisms, which will be seen to be monadic.

We shall also discuss some other adjoint situations between the categories of **QAb**, partially ordered groups, and lattice ordered groups. (Received December 13, 2010)

1069-06-89 **Kira Adaricheva*** (adariche@yu.edu), Yeshiva University, 245 Lexington ave., New York, NY 10016, and **James B Nation** (jb@math.hawaii.edu), University of Hawaii, Honolulu, HI 96822. *Ordered direct implicational basis of a finite closure system.* Preliminary report.

Closure system on a finite set is a unifying concept in logic programming, relational data bases and knowledge systems. It can also be presented in the terms of finite lattices, and the tools of "economic description" of a finite lattice have long existed in lattice theory. We present this approach by describing the so-called D-basis and introducing the concept of *ordered direct basis* of an implicational system. *A direct basis* of a closure operator, or an implicational system, is the set of implications that allows one to compute the closure of arbitrary set by a single application of each implication. This property is preserved by D-basis at the cost of following a prescribed order in which implications will be applied. In particular, this allows us to optimize *the forward chaining procedure* in logic programming that uses the Horn fragment of propositional logic. We show that one can extract the D-basis from any direct unit basis Σ in time polynomial of $|\Sigma|$, and it takes only linear time of the size of D-basis to put it into a proper order. (Received January 15, 2011)

1069-06-150 **M. E. Adams***, Department of Mathematics, State University of New York, New Paltz, NY 12561, **W. Dziobiak**, Department of Mathematics, University of Puerto Rico, Mayagüez, PR 00681, and **H. P. Sankappanavar**, Department of Mathematics, State University of New York, New Paltz, NY 12561. *Endomorphisms and Homomorphisms of Quasi-Stone Algebras.* Preliminary report.

The lattice of varieties of quasi-Stone algebras ordered by inclusion is an $\omega+1$ chain $(\mathbf{Q_i} : 0 \leq i < \omega+1)$, where $\mathbf{Q_0}$ is the trivial variety and $\mathbf{Q}_\omega$ is the variety of all quasi-Stone algebras. It is shown that the variety $\mathbf{Q_{14}}$ is finite-to-finite universal (in the sense of Hedrlín and Pultr). It follows, for example, that for any monoid M, there exists a proper class of non-isomorphic quasi-Stone algebras in $\mathbf{Q_{13}}$ each of which has an endomorphism monoid isomorphic to M. Further, it is shown that this is sharp; namely, the variety $\mathbf{Q_{13}}$ is not universal. However, $\mathbf{Q_{10}}$ is shown to be finite-to-finite universal relative to $\mathbf{Q_9}$; this too is sharp. Consequences of these facts and their relationship to quasivarieties are also discussed. (Received January 21, 2011)

1069-06-194 **Peter Jipsen*** (jipsen@chapman.edu), Chapman University, Mathematics, School of Computational Science, Von Neumann Hall, 545 W. Palm Ave, Orange, CA 92866. *Some results obtained with the Universal Algebra Calculator, theorem provers and constraint satisfiers in a Sage package.*

Sage (sagemath.org) is a free research-oriented computer algebra system that includes tools like GAP and Maxima. To make it convenient for research in Universal Algebra, we are developing a package for Sage that incorporates the Kiss-Freese-Valeriote UA Calculator (uacalc.org) as well as Prover9/Mace4 (prover9.org) for first-order reasoning and Minion (minion.sourceforge.net) for constraint satisfaction.

We indicate how these tools are used to implement standard universal algebra constructions like HS(A) in a reasonably efficient way. As an application we investigate the HS-poset of subdirectly irreducible lattices up to size 10. We also use Birkhoff's duality between ortholattices and graphs to construct all finite ortholattices with up to 8 join-irreducibles. In a non-CD-setting we examine subvarieties of bi-semilattices using the $A \in \mathrm{Var}(B)$ implementation of the UA Calculator.

Finally, we consider ℓ-pregroups, i.e. lattice-ordered monoids with operations x^l, x^r that satisfy $x^l x \leq 1 \leq x x^l$ and $x x^r \leq 1 \leq x^r x$. Jointly with N. Galatos, we show that ℓ-pregroups that satisfies $x^{l^n} = x^{r^n}$ for some $n > 0$ have distributive lattice reducts, and discuss how parts of the proof were found with the equational theorem prover Waldmeister. (Received January 23, 2011)

08 ► General algebraic systems

1069-08-24 **Peter Mayr*** (stein@cii.fc.ul.pt), Centro de Algebra de Universidade de Lisboa, Av. Prof. Gama Pinto 2, 1649-003 Lisboa, Portugal. *On the subpower membership problem for Malcev algebras.* Preliminary report.

At the Conference on Order, Algebra, and Logics in Nashville 2007, Ross Willard proposed the socalled subpower membership problem. Fix a finite algebra $\mathbf{A}$.

INPUT $X \subseteq A^n, y \in A^n$

PROBLEM Is y in the subalgebra of $\mathbf{A}^n$ that is generated by X?

Marcin Kozik constructed algebras for which this decision problem is Exptime-complete. However, Willard observed that for groups and rings there is a polynomial-time algorithm, and he asked whether the subpower membership problem is in P for all Malcev algebras. We show that it is in NP for arbitrary Malcev algebras

and that it is solvable in polynomial time for various instances: e.g., algebras of size 2, expansions of elementary abelian groups, ... The general question remains open. (Received January 26, 2011)

1069-08-30 **Anna Mućka**, **Anna Romanowska** and **Jonathan D.H. Smith*** (jdhsmith@iastate.edu), Department of Mathematics, 396 Carver Hall, Iowa State University, Ames, IA 50011-2064. *Many-sorted and single-sorted algebras.*

We specify a detailed and general method for translating the class of all pure, many-sorted algebras of a given constant-free type into an equivalent variety of single-sorted algebras of defined, constant-free type. (Received December 01, 2010)

1069-08-35 **Keith A Kearnes*** (kearnes@euclid.colorado.edu), Department of Mathematics, University of Colorado, Boulder, CO 80309-0395, and **Yingwei Li**, Department of Mathematics, Indiana University, Bloomington, IN 47405. *Locally finite varieties with $\langle R, S\rangle$-irreducible sets of bounded size.*

Tame congruence theory studies the polynomial structure of a finite algebra via its $\langle\alpha, \beta\rangle$-minimal sets, where α and β are congruences. It is not hard to prove that a locally finite variety has a finite bound on the size of the $\langle\alpha, \beta\rangle$-minimal sets of its members if and only if it is congruence distributive. $\langle\alpha, \beta\rangle$-minimal sets are special cases of $\langle R, S\rangle$-irreducible sets, where R and S are general compatible relations. This talk is about the theorem that a finitely generated variety has a finite bound on the size of the $\langle R, S\rangle$-irreducible sets of its members if and only if it is congruence 3-permutable and has a near unanimity term. (Received December 09, 2010)

1069-08-52 **Joel Berman*** (jberman@uic.edu), Department of Mathematics (m/c 249), 851 S. Morgan, University of Illinois at Chicago, Chicago, IL 60607. *Maximal n-generated subdirect products.* Preliminary report.

For n a positive integer and K a finite set of finite algebras, let $\mathbf{L}(n, K)$ denote the largest n-generated subdirect product whose subdirect factors are algebras in K. For finite $\mathbf{A}$ the algebra $\mathbf{L}(n, \{\mathbf{A}\})$ is the largest n-generated subdirect power of $\mathbf{A}$.

For every n and finite $\mathbf{A}$ we provide an upper bound on the cardinality of $\mathbf{L}(n, \{\mathbf{A}\})$. This upper bound depends only on n and the basic parameters: the cardinality of the automorphism group of $\mathbf{A}$, the cardinalities of the subalgebras of $\mathbf{A}$, and the cardinalities of the equivalence classes of certain equivalence relations arising from congruence relations of $\mathbf{A}$. Using this upper bound on n-generated subdirect powers of $\mathbf{A}$, as $\mathbf{A}$ ranges over the n-generated subdirectly irreducible algebras in a locally finite variety $\mathcal{V}$, we obtain an upper bound on the cardinality of free algebra for $\mathcal{V}$ on n free generators. If all the n-generated subdirectly irreducible algebras in $\mathcal{V}$ have congruence lattices that are chains, then we characterize those $\mathcal{V}$ for which this upper bound on the size of the free algebras is obtained. (Received January 05, 2011)

1069-08-83 **Clifford Bergman*** (cbergman@iastate.edu) and **Joel Berman** (jberman@uic.edu). *Quasiprimal algebras and verbose varieties.* Preliminary report.

Let $\mathcal{V}$ be a variety and $\mathbf{A}$ an algebra of the same similarity type as $\mathcal{V}$. We define $\lambda_{\mathcal{V}}^{\mathbf{A}}$ to be the smallest congruence, θ, on $\mathbf{A}$ such that $\mathbf{A}/\theta \in \mathcal{V}$. Congruences of this form are called *verbal*. A congruence θ on $\mathbf{A}$ is called *fully invariant* if, for every endomorphism f of $\mathbf{A}$, $(a, b) \in \theta \implies \big(f(a), f(b)\big) \in \theta$.

An variety is called *verbose* if every fully invariant congruence on every member algebra is verbal. In this talk we discuss the question of whether every quasiprimal algebra generates a verbose variety. (Received January 14, 2011)

1069-08-86 **Matthew Smedberg*** (matthew.smedberg@vanderbilt.edu), 1326 Stevenson Center, Vanderbilt University, Nashville, TN 37240. *Subdirectly irreducible groupoids in a category investigated by Laver.* Preliminary report.

A groupoid $\mathbf{B}$ (an algebra in a signature containing a single binary operation "$\cdot$") is left-distributive (LD) if $\mathbf{B} \models \forall x, y, z \quad x \cdot (y \cdot z) \approx (x \cdot y) \cdot (x \cdot z)$. In the context of set theory, Laver introduced a family of finite LD groupoids $\mathbf{A}_n$ and proved that a certain large cardinal axiom implies that the free algebra $\mathbf{F}_{LD}(1)$ is isomorphic to a subalgebra of the inverse limit $\varprojlim \mathbf{A}_n$. The problem of removing the large cardinal hypothesis is open. In this talk I extend results of Drapal to classify the subdirectly irreducible monogenerated LD groupoids, which (by a celebrated theorem of Birkhoff) have a canonical relationship to the free algebra $\mathbf{F}_{LD}(1)$, and discuss possible avenues of approach to Laver's Problem. (Received January 14, 2011)

1069-08-98 **Steve Seif*** (swseif01@louisville.edu), Math Department, University of Louisville, Louisville, KY 40292. *Transitivity and representation of finite lattices by finite algebras.*

This talk will explore the role of transitivity in the congruence theory of arbitrary algebras. The two-part open problem below gives some of the flavor of the talk. An M-Set $\mathbf{X} = \langle X, N\rangle$ is a unary algebra such that N is a monoid of transformations of X, and a finite lattice L is representable by $\mathbf{X}$ if $L \cong Con(\mathbf{X})$. A finite lattice L is **Tr-representable** by $\mathbf{X}$ if L is representable by $\mathbf{X}$ but whenever S is a proper submonoid of N, then $\langle X, S\rangle$ does not represent L. **Problem.** 1. Prove or disprove: If every finite lattice is representable (and therefore representable by a finite G-Set), then every finite lattice is *Tr*-representable. 2. Is every representable finite lattice also *Tr*-representable? Results of the author involving transitivity aspects of congruence theory will be presented. (Received January 17, 2011)

1069-08-103 **Marcin Kozik** and **Ross Willard*** (rdwillar@uwaterloo.ca). *A new property of finite NU(4) algebras.*

Motivated by CSP fine classification speculations of Larose and Tesson, we study a new property of finite algebras with a near unanimity term operation.

Definition. Suppose $\mathbf{A}$ is a finite $NU(k)$ algebra with near unanimity term operation $m(x_1, \dots, x_k)$.

(1) If $\mathbf{B}, \mathbf{C} \in V(\mathbf{A})$ with $\mathbf{B} \leq \mathbf{C}$, we say that $\mathbf{B}$ *absorbs* $\mathbf{C}$ if $m(c_1, \dots, c_k) \in B$ whenever $c_1, \dots, c_k \in C$ with at most one c_i *not* in B.

(2) We call $a \in A$ a *universal constant* for $\mathbf{A}$ provided the following holds: for all $n \geq 1$, for all $\mathbf{B} \leq \mathbf{C} \leq \mathbf{A}^n$, if (i) $\mathbf{B} \leq_{sd} \mathbf{A}^n$, (ii) $\mathbf{B}$ absorbs $\mathbf{C}$, and (iii) $\mathbf{C}$ contains the constant n-tuple $\hat{c} = (c, \dots, c)$ for every $c \in A$, then $\hat{a} \in B$.

Theorem. Every finite $NU(4)$ algebra has a universal constant.

Question: Does every finite $NU(k)$ algebra have a universal constant? (Received January 17, 2011)

1069-08-157 **Libor Barto*** (libor.barto@gmail.com), 1280 Main Street West, Hamilton, Ontario L8S 4K1, Canada. *Applications of the Constraint Satisfaction Problem to Universal Algebra.*

In last ten years universal algebra has played a major role in the study of the complexity of constraint satisfaction problems (CSPs). On the other hand, techniques developed for the CSP has brought new results and insights to universal algebra. In the talk I will discuss some examples of such applications. (Received January 21, 2011)

1069-08-174 **Jennifer Hyndman*** (hyndman@unbc.ca), Mathematics and Statistics, University of Northern British Columbia, 3333 University Way, Prince George, BC V2N 4Z9, Canada. *Quasi-equations of finite unary algebras with* 0.

Previous work has shown that if $\mathbf{M}$ is a finite unary algebra such that $\leq$ or $+ \bmod n$ can be defined from the operations using primitive positive formulas then $\mathbf{M}$ does not have a finite basis for its quasi-equations.

When $\mathbf{M}$ is a finite unary algebra that has an element 0 that is both a subalgebra and a constant function let $\mathbf{Rows}(\mathbf{M})$ denotes the table of values obtained from all non-trivial operations in the clone of $\mathbf{M}$. When the elements in this table take on exactly two values and the rows of the table form an order ideal then $\mathbf{M}$ has a finite basis of its quasi-equations. In contrast, other simple conditions on $\mathbf{Rows}(\mathbf{M})$ imply that either $\leq$ or $+ \bmod 2$ can be primitively positively defined so that $\mathbf{M}$ does not have a finite basis for its quasi-equations. (Received January 22, 2011)

1069-08-180 **Agnes E Szendrei***, a.szendrei@math.u-szeged.hu. *A Separation Theorem for the Clone of Nonsurjective Operations.* Preliminary report.

On a fixed finite base set, let $\mathcal{S}^-$ be the clone consisting of the projections and all nonsurjective operations, and let $\{\rho\}^\perp$ denote the clone of all operations that preserve the relation ρ. We will present a finite family R of relations such that (i) for any clone $\mathcal{C}$ we have $\mathcal{S}^- \not\subseteq \mathcal{C}$ iff $\mathcal{C} \subseteq \{\rho\}^\perp$ for some $\rho \in R$; and (ii) the clones $\{\rho\}^\perp$ ($\rho \in R$) are pairwise incomparable. (Received January 22, 2011)

1069-08-217 **John W. Snow*** (John.Snow@cune.edu), **Jeremy Alm** and **Kristi Meyer**. *Problems in Universal Algebra and the Theory of Ordered Sets.* Preliminary report.

We will survey several outstanding problems in universal algebra and the theory of ordered sets. (Received January 24, 2011)

1069-08-288 **Marcel G. Jackson**, Department of Mathematics and Statistics, LaTrobe University, Bundoora, Victoria 3086, Australia, and **George F Mcnulty*** (mcnulty@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208. *Lyndon's Algebra: a study of equational complexity and the finite algebra membership problem.*

In 1954 Roger Lyndon gave the earliest example of a finite algebra, denoted here by **L**, with a nonfinitely based equational theory. Z. Szekely noticed 40 years later that **L** is associated with a finite automaton and so belongs to the class of automatic algebras. Roughly speaking the equational complexity of an algebra **A** is a function $\beta(n)$ measuring how much of the equational theory of **A** must be examined to determine whether an algebra of size bounded by n belongs to the variety generated by **A**. The finite algebra membership problem for **A** is the problem of deciding, given a finite algebra **B**, whether **B** belongs to the variety generated by **A**. We show the following about Lyndon's algebra:

(1) The equational complexity of **L** lies between $n-4$ and $2n+1$.

(2) The finite algebra membership problem of **L** is decidable in nondeterministic logarithmic space (and hence in polynomial time).

(3) The variety generated by **L** has subdirectly irreducible algebras of every cardinality bigger than 1 except 4.

(4) **L** is inherently nonfinitely based relative to the variety generatetd by all automatic algebras.

(Received January 25, 2011)

11 ► Number theory

1069-11-3 **Kevin B. Ford*** (ford@math.uiuc.edu), University of Illinois Urbana-Champaign, Department of Mathematics, 1409 West Green St., Urbana, IL 61801, **Sergei V. Konyagin** (konyagin@mi.ras.ru), 8 Gubkin Street, Moscow, 119991, Russia, and **Florian Luca** (fluca@matmor.unam.mx), Ap. Postal 61-3 (Xangari), C.P. 58089, Morelia, Mexico. *Prime chains, arithmetic functions and branching random walks.*

A "prime chain" is a sequence of primes $p_1, \dots, p_k$ with $p_j | (p_{j+1} - 1)$ for each j. For example, 3, 7, 29, 59, 709. Prime chains are multiplicative analogs of the well-studied additive prime k-tuples, and have arisen in the study of the complexity of primality certificates and the distribution of arithmetic functions such as $\phi(n)$, Euler's totient function. and $\sigma(n)$, the sum of divisors function. We describe new estimates for counts of prime chains of certain types and applications to these problems. In particular, we solve a 1958 problem of Erdős by showing that the equation $\phi(n) = \sigma(m)$ has infinitely many solutions (m, n).

We also discuss the distribution of $H(p)$, which is the length of the longest chain ending at a given prime p, and also the height of the "Pratt tree" for p, the tree structure of all prime chains ending at p, which was used by V. Pratt in 1975 to show that the set of primes is in the comutational complexity class NP. We give new, nontrivial bounds for $H(p)$ valid for most p, and introduce a stochastic model of $H(p)$, the analysis of which depends on the theory of branching random walks.

Finally, we discuss other uses of branching processes to study number theoretic phenomena. (Received October 18, 2010)

1069-11-65 **Liang Xiao*** (lxiao@math.uchicago.edu), 5734 South University Ave, Eckhart 312, Chicago, IL 606375418. *Computing log-characteristic cycles using ramification theory.*

There is an analogy among vector bundles with integrable connections, overconvergent F-isocrystals, and lisse l-adic sheaves. Given one of the objects, the property of being clean says that the ramification is controlled by the ramification along all generic points of the ramified divisors. In this case, one expects that the Euler characteristics may be expressed in terms of (subsidiary) Swan conductors; and (in first two cases) the log-characteristic cycles may be described in terms of refined Swan conductors. I will explain the proof of this in the vector bundle case and report on the recent progress on the overconvergent F-isocrystal case if time is permitted. (Received January 11, 2011)

1069-11-80 **Min Ho Lee***, Department of Mathematics, Cedar Falls, IA 50614. *Modular polynomials and quasimodular forms.*

Modular polynomials are polynomials whose coefficients are modular forms of certain type, and they are in one-to-one correspondence with quasimodular polynomials that are naturally associated to quasimodular forms. In addition to the formal derivative operator ∂_X, there is a differential operator $\mathcal{D}_\lambda$ on quasimodular polynomials corresponding to the derivative operator on quasimodular forms. We discuss linear maps of quasimodular

polynomials corresponding to certain linear maps of modular polynomials, which reduce to the operators $\mathcal{D}_\lambda$ and ∂_X in special cases. (Received January 14, 2011)

1069-11-90 **A. Raghuram*** (araghur@math.okstate.edu), Department of Mathematics, 401 Mathematical Sciences, Oklahoma State University, Stillwater, OK 74078. *Eisenstein cohomology and special values of Rankin-Selberg L-functions.*

I will introduce the notion of Eisenstein cohomology and show how one can use it to prove algebraicity results for ratios of successive critical values for the Rankin-Selberg L-functions for GL(n) x GL(m) under the parity restriction that n+m is odd. This is joint work with Guenter Harder, and it generalizes previous work of Harder in the case of GL(2) x GL(1), and complements my own results on GL(n) x GL(n-1). (Received January 16, 2011)

1069-11-104 **Bei Zhang*** (zbtai@math.northwestern.edu), 2033 Sheridan Road, Evanston, IL 60208. *p-adic L-function of automorphic form of GL(2).* Preliminary report.

Modular symbol is used to construct p-adic L-functions associated to a modular form. In this talk, I will explain how to generalize this powerful tool to the construction of p-adic L-functions attached to an automorphic representation on $GL_2(\mathbb{A})$ where $\mathbb{A}$ is the ring of adeles over a number field. This is a joint work with Matthew Emerton. (Received January 17, 2011)

1069-11-126 **A. Raghuram** (araghur@math.okstate.edu) and **Naomi Tanabe*** (ntanabe@math.okstate.edu), 401 Math Science, Oklahoma State University, Stillwater, OK 74078. *Special Values of L-functions attached to Hilbert Modular Forms.*

In this talk, we give another proof for Shimura's theorem about special values of the L-function of a holomorphic Hilbert modular form, using a cohomological point of view. (Received January 19, 2011)

1069-11-132 **Tim Lee Gillespie*** (tim-gillespie@uiowa.edu), 226 Schaeffer Hall, University of Iowa, Iowa City, IA 52246. *Zero Statistics of Automorphic L-functions and Cyclic Base Change.*

Let π and π' be two automorphic cuspidal representations defined on $GL_n(\mathbb{A}_E)$ and $GL_m(\mathbb{A}_F)$, respectively, with E and F cyclic algebraic number fields of prime degree. We use a prime number theorem for a generalized Rankin-Selberg L-function $L(s, \pi \times_{E,F} \pi')$ to put necessary conditions on the factorization of an L-function into a product of primitive L-functions, with each factor defined on $GL_k(\mathbb{A}_L)$, for L cyclic of prime degree. (Received January 20, 2011)

1069-11-137 **Scott Ahlgren*** (ahlgren@math.uiuc.edu), Department of Mathematics, University of Illinois, 1409 W. Green St, Urbana, IL 61801. *p-adic properties of modular and mock modular forms.*

I will describe explicit Hecke-type congruences modulo arbitrary powers of primes for families of weight 3/2 modular and mock modular forms. There are applications to generating functions of combinatorial and number theoretic interest (including the"smallest parts" partition function of Andrews and Zagier's generating function for the traces of singular moduli). Some of this is joint work with Kathrin Bringmann and Jeremy Lovejoy. (Received January 20, 2011)

1069-11-170 **Youness Lamzouri*** (lamzouri@math.uiuc.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W. Green St, Urbana, IL 61801. *The distribution of extreme values of L-functions in the critical strip.*

In this talk, I will present new results on the distribution of extreme values of several families of L-functions inside the critical strip. We consider the Riemann zeta function $\zeta(s)$ in the t-aspect, Dirichlet L-functions in the q-aspect, and L-functions attached to primitive holomorphic cusp forms of weight 2 in the level aspect. For each family we show that the L-values can be very well modeled by an adequate random Euler product, uniformly in a wide range. Furthermore, under the assumption of the Generalized Riemann Hypothesis, we establish new Ω-results for quadratic Dirichlet L-functions, which are predicted to be best possible by the corresponding probabilistic model. (Received January 22, 2011)

1069-11-200 **James W Cogdell*** (cogdell@math.ohio-state.edu), Department of Mathematics, Ohio State University, 231 W. 18th Avenue, Columbus, OH 43210. *On the local exterior square L-function for $GL(n)$.*

There has been renewed interest in the local exterior square L-function for $GL(n)$, both in its own right and for global applications. In this talk I would like to survey some ideas, both old and new, for thinking about this and then some results. Time permitting, these will include the method of "Derivatives and L-functions" for

computing the local L-function, some recent results of Kewat and Belt about non-vanishing, and new ideas of Shahidi and Tsai to attack the stability of the local γ-factor. (Received January 23, 2011)

1069-11-227 **Wen-Ching Winnie Li** and **Ling Long*** (linglong@iastate.edu), 452 Carver Hall, Iowa State University, Ames, IA 50011. *Fourier coefficients of noncongruence cuspforms.*

Among all finite index subgroups of the modular group, majority of them are noncongruence, that is their group members cannot be described in terms of congruences. It is a commonly believed that the coefficients of genuine holomorphic noncongruence modular forms having algebraic coefficients have unbounded denominators. This conjecture has far-reaching impacts on arithmetic and beyond. In this talk, we will give partial supportive results to this conjecture.

Given a finite index subgroup of the modular group whose modular curve is defined over the field of rationals, under the assumption that the space of (weight at least 2) cusp forms is 1-dimensional, we show that a form in this space with rational Fourier coefficients has unbounded denominators if and only if it is a noncongruence modular form. (Received January 24, 2011)

1069-11-243 **Michael C Woodbury*** (woodbury@math.wisc.edu), 480 Lincoln Dr., Madison, WI 53706-1388. *Trilinear forms, the triple product L-function and subconvexity.*

In studying L-functions, the general method of convexity can be used to give certain bounds on the values of L-functions in families. While the best expected bounds due from the generalized Riemann hypothesis would have many more applications, even just a slight improvement over the convex bound is often quite useful. Such a bound is called subconvexity. Recently Bernstein and Reznikov proved subconvexity of the triple product L-function in the "eigenvalue aspect" using an integral representation of the L-value provided by work of Watson. I will discuss how I a formula of Ichino can be used to generalize Watson's result, and how together with work of Venkatesh gives subconvexity in the "level aspect." (Received January 24, 2011)

1069-11-284 **luanlei zhao*** (zhao@math.wisc.edu), 503 eagle heights apt H, madison, WI 53705. *Integrals of automorphic Green functions.*

Following S. Kudla, J. Bruinier and T. Yang, we compute the integral of an automorphic Green functions coming from vector valued harmonic Maass forms for the dual pair $(O(n), Sp(1))$ over the negative 2-planes with signture (r,2) for $0 \leq r \leq n$, which is of interest in Arakelov geometry. Specially, we generalize their results in different respects. If time permits, we will talk about some examples. (Received January 24, 2011)

1069-11-289 **Daniel W File*** (daniel-file@uiowa.edu). *On the degree 5 L-function for GSp(4).*

I will describe a new integral representation for the degree five L-function of a cuspidal automorphic representation of GSp(4). The integral makes use of the Bessel model for GSp(4). (Received January 25, 2011)

1069-11-298 **Jaime Lust*** (jaime-lust@uiowa.edu). *Depth-zero supercuspidal L-packets for GSp_4.*

In 2007 Gan and Takeda proved the local Langlands conjecture for GSp_4. Under their parametrization, the L-packet attached to a L-parameter does not give an explicit realization of supercuspidal representations as compactly induced from open compact mod center subgroups. Independently, for tame regular discrete L-parameters of unramified p-adic groups, DeBacker and Reeder attached L-packets of depth-zero compactly induced supercuspidal representations. We will show that the two parametrizations agree. (Received January 25, 2011)

1069-11-305 **Ramin Takloo-Bighash*** (rtakloo@math.uic.edu), Department of Math, Stat, and Comp Sci, University of Illinois at Chicago, 851 S Morgan St (M/C249), Chicago, IL 60607. *Subrings of $\mathbb{Z}^n$ for small n.*

I will report on a recent work, joint with Nathan Kaplan, in which we study the distribution of subrings of $\mathbb{Z}^n$ of bounded additive index for small n using techniques of p-adic integration. (Received January 25, 2011)

1069-11-306 **Angel V Kumchev*** (akumchev@towson.edu), Department of Mathematics, Towson University, Towson, MD 21252, and **Taiyu Li**. *Applications of sieve methods to some additive problems about squares of primes.* Preliminary report.

We will discuss several recent applications of prime-detecting sieve methods to problems in additive prime number theory involving squares of primes. These include joint work of the presenter with J.Y. Liu and G. Harman on exceptional sets for sums of three and four squares of primes as well as recent work of the authors on sums of "almost equal" squares of primes. (Received January 25, 2011)

1069-11-360 **Craig S Franze*** (craig.s.franze@gmail.com). *A Weighted Selberg Sieve.* Preliminary report.

The best known bounds concerning almost primes in polynomial sequences come from a weighted form of the Diamond, Halberstam, Richert (DHR) sieve. However, it is known that if the sieve dimension κ is sufficiently large, then Selberg's lower bound sieve is superior to the DHR sieve. Therefore, a weighted form of Selberg's sieve should be capable of improving these bounds. This is indeed the case, at least in some instances. I will present the new bounds and compare the two weighted sieves. (Received January 26, 2011)

13 ► Commutative rings and algebras

1069-13-15 **Abdeslam Mimouni*** (amimouni@kfupm.edu.sa), Department of Mathematics and Statistics, King Fahd University of Petroleum & Minerals, Dhahran, Estern 31261, Saudi Arabia, and **Mohammed Kabbour** and **Najib Mahdou**. *Transfer of Arithmetical-like Properties to Trivial Extensions.*

In this paper we investigate the transfer of the notions of elementary divisor ring, Hermite ring, Bezout ring and arithmetical ring to trivial ring extensions of commutative rings by modules. We provide necessary and sufficient conditions for $R = A \propto E$ to be an arithmetical ring where E is a non-torsion or finitely generated A-module. Particularly, we prove that $A \propto A$ is an arithmetical ring if and only if A is a von Neumann regular ring, and $A \propto Q(A)$ is an arithmetical ring if and only if A is a semi-hereditary ring. (Received November 12, 2010)

1069-13-27 **D. D. Anderson** (dan-anderson@uiowa.edu), Department of Mathematics, The University of Iowa, Iowa City, IA 52242, and **Sangmin Chun*** (schun@snu.ac.kr), Department of Mathematics, Seoul National University, Seoul, 151-747, South Korea. *Weak Cohen-Kaplansky rings.*

Let R be a commutative ring with identity. A nonunit a∈R is called an atom or said to be irreducible if whenever a=bc, b,c∈R, then (a)=(b) or (a)=(c) and R is said to be atomic if each nonunit of R is a finite product of atoms. R is called a (weak) Cohen-Kaplansky ring, or a (weak) CK ring for short, if R is atomic and (each maximal ideal of) R contains only finitely many nonassociate atoms. We show that the following conditions are equivalent: (1) R is a weak CK ring, (2) every (prime) ideal of R is a finite union of principal ideals, (3) R is atomic and every maximal ideal of R is a finite union of principal ideals, (4) R is a finite direct product of SPIRs, finite local rings and (one-dimensional) Noetherian domains in which every maximal ideal is a finite union of principal ideals, or equivalently, weak CK domains. The last equivalence effectively reduces the study of weak CK rings to weak CK domains. It is shown that an integral domain D is a weak CK domain if and only if D is Noetherian, for each maximal ideal M of D, D_M is a CK domain, and Pic(D)=0. (Received November 30, 2010)

1069-13-57 **David F Anderson** and **Ayman R Badawi*** (abadawi@aus.edu), American University of Sharjah, Dept of Mathematics, P.O. Box 26666, Sharjah, 26666, United Arab Emirates. *On the total graph of a commutative ring without the zero element.* Preliminary report.

Let R be a commutative ring with nonzero identity, and let $Z(R)$ be its set of zero-divisors. The total graph of R is the (undirected) graph $T(\Gamma(R))$ with vertices all elements of R, and two distinct vertices x and y are adjacent if and only if $x + y \in Z(R)$. In this paper, we study the two (induced) subgraphs $Z_0(\Gamma(R))$ and $T_0(\Gamma(R))$ of $T(\Gamma(R))$, with vertices $Z(R) \setminus \{0\}$ and $R \setminus \{0\}$, respectively. We determine when $Z_0(\Gamma(R))$ and $T_0(\Gamma(R))$ are connected and compute their diameter and girth. We also investigate zero-divisor paths and regular paths in $T_0(\Gamma(R))$. (Received January 09, 2011)

1069-13-63 **Peter Malcolmson** and **Frank Okoh*** (okoh@math.wayne.edu), Department of Mathemetics, Wayne State University, Detroit, MI 48202. *Factorization properties of some affine domains.* Preliminary report.

Let D be an integral domain. For any element $a \in D$, let $\mathrm{Irr}(a)$ denote the set of non-associate irreducible divisors of a in D. We recall that an integral domain D is *locally finitely generated* (or *irreducible divisors of powers finite*, IDPF) if, for any non-zero element $a \in D$, the set $\cup_{n=1}^{\infty}\mathrm{Irr}(a^n)$ is finite. The domain D said to be half-factorial (HFD) if every non-zero element that is a finite product of a unique number of irreducible elements.

An affine domain over a field of characteristic zero is IDPF if and only if it is integrally closed. The situation in characteristic $p > 0$ is not resolved.

As for HFD, our study is still limited to specific types of equations over **Q**. Here are samples Theorem 1.(V. Srinivas) The coordinate ring of $x^{2^n}+y^{2^n}+z^{2^n}=0$ is half-factorial if and only if $n=1$. Theorem 2. Let $n\geq 2$. The coordinate ring of $x^n+y^n=z^n$ is half-factorial if and only if $n=2$. (Received January 11, 2011)

1069-13-92 **David E. Dobbs***, Department of Mathematics, University of Tennessee, Knoxville, TN 37996-1320, and **Ronald Levy** and **Jay Shapiro**. *A universal survival ring of continuous functions which is not a universal lying-over ring, I.*

A (commutative unital nonzero) ring R is said to be a ULO- (resp., UQLO-; resp., US-) ring if each (unital) ring extension $R\subseteq S$ satisfies the LO-property (resp., satisfies the QLO-property; resp., is a survival extension). It is easy to see that $\dim(R)=0\Rightarrow$ LO-ring $\Rightarrow$ [UQLO-ring and US-ring]. The purpose of these talks is to show that essentially none of the related converses hold in general. In Part I, we study the above classes of rings and some natural connections with total quotient rings, Property A, reduced rings, Noetherian rings and Hilbert rings. We also use the $A+B$ construction to build relevant examples in any dimension greater than 1. Part I closes by noting that the above purpose would be settled if one could construct an infinite-dimensional US-ring which is not a ULO-ring. (Received January 16, 2011)

1069-13-93 **Christine Berkesch**, **Daniel Erman**, **Manoj Kummini*** (nkummini@math.purdue.edu) and **Steven Sam**. *Multilinear free resolutions from higher tensors.*

We describe a construction of free resolutions from higher tensors. Our construction provides new explicit examples of minimal free resolutions, as well as a unifying view on a wide variety of complexes including: the Eagon–Northcott, Buchsbaum–Rim and similar complexes, the Eisenbud–Schreyer pure resolutions, and the complexes used by Gelfand–Kapranov–Zelevinsky and Weyman to compute hyperdeterminants. (Received January 16, 2011)

1069-13-100 **David E. Dobbs**, **Ronald Levy** and **Jay Shapiro***, jshapiro@gmu.edu. *A universal survival ring of continuous functions which is not a universal lying-over ring.*

Part II is devoted to constructing an infinite-dimensional US-ring R which is not a ULO-ring. In fact, R can be taken to be the ring of continuous real-valued functions on the one-point compactification of the discrete space of cardinality $\aleph_1$. This ring R is also shown to have the following properties. Not only is R infinite-dimensional, but there exist chains of cardinality $\mathfrak{c}$ that consist of prime ideals of R. Moreover, R/P is a divided domain for each $P\in\operatorname{Spec}(R)$. If the Continuum Hypothesis holds, then there exists a minimal prime ideal P of R such that R/P is an infinite-dimensional valuation domain; however, it is consistent with ZFC that no such minimal primes exist. (Received January 17, 2011)

1069-13-111 **Peter Malcolmson*** (petem@math.wayne.edu), Department of Mathematics, Wayne State University, Detroit, MI 48202, and **Frank Okoh**, Department of Mathematics, Wayne State University, Detroit, MI 48202. *Root extensions of subrings of quadratic number rings.*

A commutative ring S is said to be a *radical* or *root* extension of a subring R if for each element s in S there is a positive integer k such that s^k is in R. It is known that an algebra over a field of characteristic zero is not a root extension of any proper subalgebra. In this paper we determine which subrings R of a maximal quadratic number ring S have S as a root extension. Whether S is a root extension of R reflects both the arithmetic and factorization properties of R. We show that this remains the case for localizations, polynomial ring extensions, and power series extensions of R and S. (Received January 18, 2011)

1069-13-117 **Chris Spicer*** (spicer@morningside.edu), Sioux City, IA 51106-1717, and **Jim Coykendall** (jim.coykendall@ndsu.edu), Fargo, ND 58108-6050. *A Cohen-Kaplansky Domain Construction.* Preliminary report.

A Cohen-Kaplansky domain is an atomic domain with only a finite number of irreducibles (up to associates). We define a CK-n domain to be a CK-domain containing precisely n distinct nonprime irreducibles. We will consider a construction of CK-domains using extensions of power series of the form $\mathbb{F}[[x^{a_1},x^{a_2},\ldots,x^{a_n}]]$, with each $a_i\geq 2$ and $\mathbb{F}$ a finite field. The proof that domains of this type form CK-domains requires several unexpected number-theoretic results which will be discussed. (Received January 19, 2011)

1069-13-118 **Jeremiah Reinkoester*** (reinkoester_jn@mercer.edu), Department of Mathematics, Mercer University, Macon, GA 31207, and **Dan Anderson**, Department of Mathematics, The University of Iowa, Iowa City, IA 52242. *Generalized Relative Primeness.* Preliminary report.

Let D be an integral domain. We are interested in "relatively prime" relations τ on $D^{\#}$, the nonzero nonunits of D, that is, relations that share properties with the three relations: a and b are comaximal, a and b are v-coprime

$(((a,\ b)^{-1})^{-1} = D)$, and a and b are relatively prime. Of particular interest are relations of the form $\tau_{\mathbb{S}}$ for a set $\mathbb{S}$ of proper ideals of D where $a\ \tau_{\mathbb{S}}\ b \iff (a,b) \not\subseteq I$ for each $I \in \mathbb{S}$. Examples include $\mathbb{S} = \star\text{-}max(D)$, the maximal $\star$-ideals of a finite character star operation $\star$ on D (for $\star = d$, we get comaximal and for $\star = t$, we get v-coprime), $\mathbb{S} = \{(a) \mid a \in D^{\#}\}$ (where we get relatively prime), and $\mathbb{S} = X^{(1)}(D)$, the set of height-one prime ideals of D. We also study τ-factorization of an element a of $D^{\#}$ ($a = \lambda a_1 \cdots a_n$, λ a unit, $a_i \in D^{\#}$, $a_i\ \tau\ a_j$ for $i \neq j$) into τ-atoms (each τ-factorization has length one). (Received January 19, 2011)

1069-13-125 **Marco Fontana**, **Evan Houston** and **Thomas Lucas*** (tglucas@uncc.edu).
Pseudo-Dedekind Factorization. Preliminary report.

A nonzero ideal I of an integral domain R is said to have a pseudo-Dedekind factorization if there is an invertible ideal J (which may be R) and finitely many pairwise comaximal prime ideals $P_1, P_2, \ldots, P_n$ with $n \geq 1$ such that $I = JP_1P_2 \cdots P_n$. The domain R has pseudo-Dedekind factorization if each nonzero noninvertible ideal has a pseudo-Dedekind factorization. This is a slightly weaker notion than that of a ZPUI domain (which is equivalent to each nonzero ideal has a pseudo-Dedekind factorization). In particular, each ZPUI domain is a Prüfer domain, but there are domains with pseudo-Dedekind factorization that are not integrally closed. Also, each maximal ideal of a ZPUI domain is invertible, but a rank one valuation domain whose corresponding value group is the real numbers has pseudo-Dedekind factorization. In addition, there is a valuation domain with pseudo-Dedekind factorization whose maximal ideal is unbranched. (Received January 19, 2011)

1069-13-141 **Evan Houston*** (eghousto@uncc.edu), **Abdeslam Mimouni** and **Mi Hee Park**.
Noetherian domains which admit only finitely many star operations.

We attempt to characterize Noetherian domains which admit only finitely many star operations. We succeed in reducing the problem to the case of local (Noetherian) one-dimensional domains (R, M). In the local case, it turns out to be somewhat natural to concentrate on the case where the R/M-vector space $(R : M)/M$ has dimension 3. In that case, $(R : M)$ is "often" a PID, and we are able to count the number of star operations on R precisely. (Received January 20, 2011)

1069-13-158 **Ryan Schwarz*** (schwarz@math.uconn.edu) and **Sarah Glaz** (glaz@math.uconn.edu).
Zero-Divisor and Prüfer Conditions in Commutative Group Rings.

Let R be a commutative ring, and let G be an abelian group. We consider the following zero-divisor conditions:

(1) R is a PF ring, i.e. every principal ideal of R is flat.

(2) R is a PP ring, i.e. every principal ideal of R is projective.

(3) $Q(R)$, total ring of quotients of R, is von Neumann regular.

(4) Min R, the set of minimal primes of R, is compact in the Zariski topology.

In this talk, we will discuss ascent and descent of these zero-divisor conditions between R and RG where G is either a torsion free group or R is uniquely divisible by all prime orders of elements of G. As an application, we will examine some connections between these zero-divisor conditions and Prüfer conditions in RG. (Received January 21, 2011)

1069-13-160 **John D. LaGrange*** (lagrangej@lindsey.edu). *Boolean rings and reciprocal eigenvalue properties.* Preliminary report.

Let $\{v_1, \ldots, v_n\}$ be the set of vertices of a graph Γ. An *adjacency matrix* of Γ is an $n \times n$ matrix whose (i, j)-coordinate is 1 if v_i is adjacent to v_j, and is 0 otherwise. Techniques from linear algebra become available to study a finite commutative ring R by considering the adjacency matrix of its zero-divisor graph $\Gamma(R)$. Some recent work in algebraic graph theory concerns graphs whose adjacency matrices satisfy certain *reciprocal eigenvalue properties*. Incidentally, the zero-divisor graphs of finite Boolean rings can be completely characterized by such eigenvalue properties. This characterization will be presented along with a discussion of its proof. (Received January 21, 2011)

1069-13-169 **Shashikant B. Mulay*** (mulay@math.utk.edu). *Factorization and unit-groups.* Preliminary report.

Some recent results on the factorization properties of polynomials over fields and their relationship with the unit groups of certain integral domains, will be presented. (Received January 22, 2011)

1069-13-172 **Saeed Nasseh*** (saeed.nasseh@ndsu.edu), Department of Mathematics NDSU Dept # 2750, PO Box 6050, Fargo, ND 58108-6050, and **Sean Sather-Wagstaff** (Sean.Sather-Wagstaff@ndsu.edu), Department of Mathematics NDSU Dept # 2750, PO Box 6050, Fargo, ND 58108-6050. *Lifting of semifree DG modules over DG algebras.*

Let $R \longrightarrow S$ be a homomorphism of rings and let M be a finitely generated S-module. Then the finitely generated R-module L is called a *lifting* of M to R if $M \cong S \otimes_R L$ and $\mathrm{Tor}_i^R(S, L) = 0$ for all integers $i > 0$. The S-module M is said to be *liftable* to R, when such an R-module L exists.

Let S be a Noetherian R-algebra where $(R, \mathfrak{m})$ is a commutative local ring, $\mathbf{x} = x_1, \cdots, x_n$ be an S-regular sequence in $\mathfrak{m}$ and $T = S/\mathbf{x}S$. Auslander, Ding and Solberg proved that if M is a finitely generated T-module with $\mathrm{Ext}_T^2(M, M) = 0$, then M is liftable to S. Furthermore, if N is a finitely generated T-module which is liftable to S and $\mathrm{Ext}_T^1(N, N) = 0$, then the lifting of N to S is unique.

In this talk, we are mainly concerned with the generalizations of these results for DG algebras. In particular, we investigate lifting properties for semifree DG-modules over Koszul complexes. We apply DG algebra techniques to study lifting of modules and complexes from the Koszul complex over some elements contained in the maximal ideal of a commutative complete local ring to the ring itself. (Received January 22, 2011)

1069-13-173 **Sara Shirinkam*** (sshirinkam@dena.kntu.ac.ir), **Shaban Ghalandarzadeh** (ghalandarzadeh@kntu.ac.ir) and **Parastoo Malakooti Rad** (pmalakoti@gmail.com). *On the annihilator ideal-based zero divisor graph of a ring and the torsion graph of a module.*

Let R be a commutative ring with identity and M be a unitary R-module. We define the torsion graph of M, denoted by $\Gamma(M)$, whose vertices are the non-zero torsion elements of M, and two distinct vertices x, y are adjacent if and only if $[x : M][y : M]M = 0$. We prove that if $\Gamma(M)$ contains a cycle, $gr(\Gamma(M)) \leq 4$ and that $\Gamma(M)$ has a connected induced subgraph $\bar{\Gamma}(M)$ with vertex set $\{m \in T(M)^* | Ann(m)M \neq 0\}$. Moreover, we show that for a multiplication R-module M, if $\bar{\Gamma}(M)$ is complete, then either $|M| = 4$ or $Nil(M) = V(\bar{\Gamma}(M)) \cup \{0\}$. Also, for a commutative ring R, the ideal based zero-divisor graph, denoted by $\Gamma_I(R)$, is the graph whose vertices are $\{x \in R \setminus I \mid xy \in I \text{ for some } \ y \in R \setminus I\}$, and two distinct vertices x and y are adjacent if and only if $xy \in I$. We investigate an annihilator ideal-based zero-divisor graph by replacing the ideal I with the annihilator ideal $Ann(M)$ for a multiplication R-module M. We prove that if $Nil(M) \neq 0$ and $\Gamma_{Ann(M)}(R)$ is a complemented graph, then either $|M| = 8$, $|M| = 9$ and $\Gamma_{Ann(M)}(R)$ is a star graph, or $|M| > 9$ and $Nil(M) = \{0, x\}$ for some $0 \neq x \in M$. (Received January 22, 2011)

1069-13-182 **D. D. Anderson** and **Muhammad Zafrullah*** (mzafrullah@usa.net). *Integral domains in which nonzero locally principal ideals are invertible.*

We study locally principal ideals and integral domains, called LPI domains, in which every nonzero locally principal ideal is invertible. We show that an integral domain that is a finite character intersection of LPI overrings is an LPI domain. Hence if a domain D is a finite character intersection $D = \cap D_P$ for some set of prime ideals of D, then D is an LPI domain. (Received January 23, 2011)

1069-13-202 **R M Ortiz-Albino*** (reyes.ortiz@upr.edu), University of Puerto Rico - Mayaguez, Department of Mathematics, PO BOX 9000, Mayaguez, PR 00681-9000, and **D D Anderson**. *Three Frameworks for a General Theory of Factorization.*

We discuss three different frameworks for a general theory of factorization in integral domains: τ-factorization (where τ denotes a symmetric relation on the set of nonzero nonunits of the domain), reduced τ-factorization and Γ-factorization (where Γ denotes a set). We will define all three factorizations and give examples to understand the basic idea. Also, we discuss the generalized notions of an atom, prime and the divides operator. Results on how these notions differ among them and desired structures properties, depending on which type of set or relation is considered. (Received January 23, 2011)

1069-13-221 **Bruce Olberding*** (olberdin@nmsu.edu), Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88001-8003. *Intersections of valuation rings over projective surfaces.* Preliminary report.

Let D be a two-dimensional Noetherian domain, and let X be a projective model over D; i.e., there exist $x_1, \ldots, x_n$ in D such that X is the projective scheme covered by $\mathrm{Spec}(D[\frac{x_1}{x_i}, \ldots, \frac{x_n}{x_i}])$, where $i = 1, \ldots, n$. Then there is a morphism δ from the locally ringed space $\mathrm{Zar}(D)$ of all valuation overrings of D to X. We consider subspaces Z of $\mathrm{Zar}(D)$ such that the restriction of δ to Z has fibers that are Noetherian subspaces of $\mathrm{Zar}(D)$. (A simple and easy-to-realize example of such a subspace Z is when each point x in X has at most one valuation ring in Z centered on it.) We describe the locally ringed space Z in terms of its underlying topology and its structure

sheaf of rings. This leads to some natural examples of Prüfer and almost Dedekind overrings of two-dimensional Noetherian domains. (Received January 24, 2011)

1069-13-238 **Sean Sather-Wagstaff*** (sean.sather-wagstaff@ndsu.edu), North Dakota State University. *Bass Numbers and Semidualizing Modules.* Preliminary report.

Let $(R, \mathfrak{m}, k)$ be a commutative local noetherian ring. We are interested in a question of Huneke on the rate of growth of the Bass numbers $\mu^i = \operatorname{rank}_k(\operatorname{Ext}^i(k, R))$. We will show how the existence of non-trivial semidualizing R-modules influences the behavior of these invariants, in essence reducing Huneke's to the case where R has a single non-trivial semidualizing module. (Received January 24, 2011)

1069-13-242 **Gregory Burnham**, **Zvi Rosen** and **Jessica Sidman*** (jsidman@mtholyoke.edu), Department of Mathematics and Statistics, Mount Holyoke College, South Hadley, MA 01002, and **Peter Vermeire**. *Graph curves: Equations, syzygies and secants.*

Much is known about the syzygies of smooth curves, and recently some of these results have been extended to their secant varieties. In this talk we will discuss what we may learn about syzygies of curves and their secant varieties via graph curves, which are arrangements of lines that can be viewed as combinatorial models of smooth curves. (Received January 24, 2011)

1069-13-251 **Ben J. Anderson*** (benjamin.j.anderson@ndsu.edu), NDSU Mathematics Dept #2750, PO Box 6050, Fargo, ND 58108, and **Jim Coykendall** and **Sean Sather-Wagstaff**. *Nakayama's Lemma for Ext and ascent for module structures.* Preliminary report.

Let $\varphi\colon (R, \mathfrak{m}, k) \to (S, \mathfrak{m}S, k)$ be a flat local ring homomorphism, and let M be a finitely generated R-module. We show that the following are equivalent:

(1) M has an S-module structure compatible with its R-module structure;

(2) $\operatorname{Ext}^i_R(S, M) = 0$ for $i \geq 1$;

(3) $\operatorname{Ext}^i_R(S, M)$ is finitely generated over R for $i = 1, \ldots, \dim_R(M)$;

(4) $\operatorname{Ext}^i_R(S, M)$ is finitely generated over S for $i = 1, \ldots, \dim_R(M)$;

(5) $\operatorname{Ext}^i_R(S, M)$ satisfies Nakayama's Lemma over R for $i = 1, \ldots, \dim_R(M)$.

This improves upon recent results of Frankild, Sather-Wagstaff, and Wiegand and results of Christensen and Sather-Wagstaff. (Received January 24, 2011)

1069-13-273 **K Alan Loper***, 1179 University Drive, Newark, OH 43055, and **Carmelo Finocchiaro**. *Topologies on the prime spectrum of a ring defined using ultrafilters.* Preliminary report.

Let R be a ring and let Spec(R) be the collection of all prime ideals of R. For any ideal I or R we let V(I) denote the set of all prime ideals of R which contain I. The collection of all sets V(I) constitutes the closed sets of a topology on Spec(R) known as the Zariski topology. There is a well known refinement of the Zariski topology known classically as either the constructable or patch topology. In 2008 Fontana and Loper gave an alternate formulation of the constructable/patch topology using ultrafilters. In this talk we give this ultrafilter definition and discriminate between two different types of ultrafilter limit points. This distinction gives rise to two new topologies on Spec(R) defined using ultrafilters. We call these topologies the Goldman topology (defined earlier by Picavet -without use of ultrafilters) and the strong topology. We consider questions such as when these new topologies are compact, when they are discrete and when they are identical to the constructable topology. As an application, we use these new topologies to give a characterization of when a subset of Spec(R) is compact in the Zariski topology and we give a simple characterization of Grothendieck's retrocompact sets in the Zariski topology in terms of ultrafilters. (Received January 24, 2011)

1069-13-280 **Jason Greene Boynton*** (jason.boynton@ndsu.edu), 300 Minard Hall, Fargo, ND 58108, and **Sean Sather-Wagstaff** (sean.sather-wagstaff@ndsu.edu), 300 Minard Hall, Fargo, ND 58108. *The D+M Construction and a Generalization.* Preliminary report.

In 1976 J.W. Brewer and E.A. Rutter investigated certain ring and ideal theoretic properties that behave nicely in the now well-studied D+M construction. In more recent years, it has become desirable to obtain similar results in pullback constructions of greater generality. We will survey some past and present results concerning the transfer of ring and ideal theoretic properties in a special case of a pullback diagram called a conductor square. In particular, we will investigate the transference of Noetherian-like properties in a regular conductor square. (Received January 24, 2011)

14 ► Algebraic geometry

1069-14-04 **Chiu-Chu Liu*** (ccliu@math.columbia.edu), Department of Mathematics, Columbia University, Room 623, MC 4435, 2990 Broadway, New York, NY 10027. *Open and Closed Gromov-Witten Invariants of Toric Calabi-Yau 3-Folds.*

Open and closed Gromov-Witten invariants count holomorphic maps from Riemann surfaces with or without boundaries to a Kahler manifold. We will describe results and conjectures on generating functions of open and closed Gromov-Witten invariants of a toric Calabi-Yau 3-fold. (Received January 21, 2011)

1069-14-13 **J. M. Landsberg**, Texas A&M University, and **Zach Teitler*** (zteitler@boisestate.edu), Department of Mathematics, Boise State University, 1910 University Drive, Boise, ID 83725-1555. *Ranks of polynomials.*

The Waring rank of a polynomial of degree d is the least number of terms in an expression for the polynomial as a sum of dth powers. The problem of finding the rank of a given polynomial and studying rank in general has been a central problem of classical algebraic geometry, related to secant varieties; in addition, there are applications to signal processing and computational complexity. Other than a well-known lower bound for rank in terms of catalecticant matrices, there has been relatively little progress on the problem of determining or bounding rank for a given polynomial in the last 150 years. I will describe a new, elementary lower bound, with especially nice results for some examples including monomials. (Received November 10, 2010)

1069-14-19 **Steven V Sam*** (ssam@math.mit.edu). *Schubert complexes and degeneracy loci.*

Pragacz gave an interpretation of the Thom–Porteous formula as the Euler characteristic of the Schur complex using its generic acyclicity and explicit combinatorial basis in terms of super semistandard Young tableaux. We do the same thing for Fulton's flagged analogue of the Thom–Porteous formula. In this case, the analogue of the Schur complex is a "Schubert complex" which we prove is generically acyclic and has an explicit combinatorial basis in terms of super balanced labelings. We will also make precise the statement that this gives a module-theoretic "approximation" of Schubert varieties. (Received November 21, 2010)

1069-14-33 **Jon Hauenstein**, **Nick Hein**, **Chris Hillar**, **Luis García-Puente**, **Abraham Martín del Campo**, **James Ruffo**, **Frank Sottile** and **Zach Teitler*** (zteitler@boisestate.edu), Department of Mathematics, Boise State University, 1910 University Dr., Boise, ID 83725-1555. *Experimentation at the Frontiers of Reality in Schubert Calculus.*

We describe the setup, design, and running of an experiment utilizing a supercomputer that is helping to formulate and test conjectures in the real Schubert calculus. Largely using machines in instructional computer labs during off-hours and University breaks, it has consumed in excess of 1.5 TeraHertz-years of computing in its first two years of operation, solving over 6 billion polynomial systems. This experiment can serve as a model for other large scale mathematical investigations. (Received December 08, 2010)

1069-14-74 **Allen Knutson*** (allenk@math.cornell.edu). *Puzzles, positroid varieties, and Vakil's geometric Littlewood-Richardson rule.*

Let X^ν_μ be the intersection of a Schubert variety and an opposite Schubert variety inside a Grassmannian. Its homology class $\sum_\lambda c^\nu_{\lambda\mu}[X^\lambda]$, expanded in the basis $\{[X^\lambda]\}$ of opposite Schubert classes, has coefficients that are Littlewood-Richardson numbers.

R. Vakil gave an interpretation of these coefficients, by degenerating X^ν_μ to a union of opposite Schubert varieties, in $\binom{n}{2}$ stages. I will show that each of the varieties he meets along the way corresponds to a partially-filled puzzle, and is an "interval positroid variety", which in particular means its equations (as a scheme) are very simple. Also I can show that all of his degenerations are reduced, Cohen-Macaulay, and Frobenius split.

This will allow me to give a positive formula, in the sense of [Anderson-Griffeth-Miller], for the class of X^ν_μ in T-equivariant K-theory of the Grassmannian; it is given by a sum over appropriately defined puzzles. (Received January 13, 2011)

1069-14-106 **Erik Insko** (erik-insko@uiowa.edu), Iowa City, IA , and **Alexander Yong*** (ayong@math.uiuc.edu), Math Dept, U. Illinois Urbana-Champaign, 1409 W. Green Street, Urbana, IL 61801. *Patch ideals and Peterson varieties.*

Patch ideals encode neighbourhoods of a variety in GL_n/B. For Peterson varieties we determine generators for these ideals and show they are complete intersections, and thus Cohen-Macaulay and Gorenstein. Consequently, we combinatorially describe the singular locus of the Peterson variety; give an explicit equivariant K-theory localization formula; and extend some results of [B. Kostant '96] and of D. Peterson to intersections of Peterson

varieties with Schubert varieties. We conjecture that the projectivized tangent cones are Cohen-Macaulay and Gorenstein, and that their h-polynomials are nonnegative and upper-semicontinuous. Similarly, we use patch ideals to briefly analyze other examples of torus invariant subvarieties of GL_n/B, including Richardson varieties and Springer fibers. (Received January 18, 2011)

1069-14-108 **Mahir Bilen Can*** (mcan@tulane.edu), 6823 St Charles Ave., New Orleans, LA 70118, and **Michael Joyce**. *A Kostant-Macdonald identity for special SL_n orbits in complete quadrics.*

After reviewing properties of the variety of complete quadrics we will extend the work of Akyildiz and Carrell on the cohomology of flag varieties to the special SL_n orbit closures. In particular we will prove a Kostant-Macdonald identity for the Poincare polynomials of the special orbits. If time permits we will talk about combinatorics of the Borel orbits in complete quadrics. (Received January 18, 2011)

1069-14-152 **Manoj Kummini** (nkummini@math.purdue.edu), IN , and **Uli Walther*** (walther@math.purdue.edu). *A vanishing theorem for etale cohomology.*

We present a criterion for open sets in projective n-space over a separably closed field to have étale cohomological dimension bounded by 2n-3. We use the criterion to exhibit a scheme for which étale cohomological dimension is smaller than what a conjecture of G. Lyubeznik predicts; the discrepancy is of arithmetic nature. (Received January 21, 2011)

1069-14-167 **Christine Berkesch** and **Laura Felicia Matusevich***, Department of Mathematics, Texas A&M University, Mailstop 3368, College Station, TX 77843-3368. *Torus equivariant D-modules and hypergeometric systems.*

We study systems of differential equations that are equivariant under a torus action. We are particularly interested in constructing a quotient system in fewer variables, and in investigating which properties these systems have in common. Our motivation comes from a particularly important example of this situation: the classical hypergeometric systems of Gauss, Appell, Lauricella, etc., and their equivariant counterparts introduced by Gelfand, Graev, Kapranov and Zelevinsky in the 1980s. (Received January 22, 2011)

1069-14-207 **Jose Malagon-Lopez***, jmalagon@uottawa.ca. *Equivariant Algebraic Cobordism, Part 1.*

In the first talk of two, we give a brief description of algebraic cobordism as the universal oriented cohomology theory. Then we introduce the notion of equivariant algebraic cobordism and state some of its basic properties. (Received January 23, 2011)

1069-14-230 **Erik A Insko*** (erik-insko@uiowa.edu), Department of Mathematics, 14 MacLean Hall, University of Iowa, Iowa City, IA 52242, and **Julianna Tymoczko** (julianna-tymoczko@uiowa.edu), Department of Mathematics, 14 MacLean Hall, University of Iowa, Iowa City, IA 52242. *Paving Peterson varieties by affines in all Lie types.*

Peterson varieties are closed subvarieties of the full flag variety. Peterson, and later Kostant, studied these varieties in connection with the quantum cohomology ring of the full flag variety. Rietsch used the geometry of these varieties to prove determinantal identities, similar to classical results about Vandermonde determinants. We will describe a paving by affines of the regular nilpotent Hessenbergs in arbitrary Lie types. We then use this paving to show that the homology of the Peterson variety injects into the homology of the full flag variety and to give a partial description of the cohomology class of the Peterson variety in terms of the basis of Schubert classes. (Received January 24, 2011)

1069-14-236 **Thomas Lam** and **Mark Shimozono***, Department of Mathematics, Blacksburg, VA 24061-0123. *Equivariant k-Schur functions, homology of the affine Grassmannian and Gromov-Witten invariants of G/B.*

We give an explicit rule for the Pontryagin product of the degree two class with an arbitrary Schubert class in the torus-equivariant homology ring of the affine Grassmannian of a simple algebraic group G. For classical type we also give a Pieri rule, which gives the Schubert expansion of the product of a special Schubert class (the special classes being generators) with an arbitrary one. By a result of Peterson we obtain explicit formulae for equivariant Gromov-Witten invariants for flag varieties G/B. For special linear groups our results are stronger: the formula for the Pieri constants is explicit and Graham-positive, and we realize the equivariant homology ring and its Schubert basis by defining new symmetric functions called equivariant k-Schur functions, which are defined in terms of Molev's dual Schur functions. (Received January 24, 2011)

1069-14-253 **Bruce Reznick*** (reznick@math.uiuc.edu), 1409 W. Green St., Urbana, IL 61801. *Apolarity, steampunk canonical forms and the obvious inner product.* Preliminary report.

There is an obvious and very old inner product on the vector space of complex forms of degree d in n variables, under which orthogonality identifies apolarity. We combine this with some other very old techniques to describe a few exotic canonical forms, especially for binary forms and forms of low degree. The methods are elementary, if not actually simple-minded. (Received January 24, 2011)

1069-14-283 **Kaisa Taipale***, Regents Hall of Mathematical Sciences, 1520 St. Olaf Ave, Northfield, MN 55057. *K-theoretic J-functions of flag varieties of type A.*

The (cohomological) J-function of a variety X compactly encapsulates a lot of information about the Gromov-Witten theory of X in its coefficients, which are Gromov-Witten invariants. K-theoretic Gromov-Witten theory is an extension of cohomological Gromov-Witten theory in which the GW invariants are defined as Euler characteristics of sheaves on the moduli space of stable maps. In this talk I will present formulas for the K-theoretic J-functions of flag varieties of type A. These formulas can be put to work relating the K-theoretic Gromov-Witten theories of Grassmannians and products of projective space via the abelian-nonabelian correspondence. (Received January 24, 2011)

1069-14-294 **Liviu Mare*** (liviu.mare@gmail.com), Department of Mathematics and Statistics, University of Regina, Regina, SK S4S 0A2, Canada. *Quantum type deformations of the cohomology ring of the flag manifold.*

A theorem of Givental and Kim gives a presentation of the small quantum cohomology ring of the flag manifold $F\ell_n(\mathbb{C})$. They actually show that a complete description of this ring, including the structure constants, is provided by the knowledge of the conserved quantities of the quantum Toda lattice of type A. I will present concrete ways of using the latter object in order to recover the quantum Chevalley, quantum Giambelli, and the "quantization via standard monomials" formulas of Fomin, Gelfand, and Postnikov. Then I will explain that if we replace the Toda lattice by a certain *periodic* version of it, the Givental-Kim approach leads to a certain deformation with n parameters of the usual cohomology ring of $F\ell_n(\mathbb{C})$. (Received January 25, 2011)

1069-14-339 **Alexander K. Woo*** (woo@stolaf.edu). *Local complete intersection Schubert varieties.* Preliminary report.

We characterize Schubert varieties which are local complete intersections (lci) by pattern avoidance conditions. For the Schubert varieties which are local complete intersections, we give an explicit minimal set of equations cutting out their neighborhoods at the identity. Using the work of Akyildiz, Lascoux, and Pragacz, we can then recover presentations for the cohomology rings of lci Schubert varieties. Included is the case of Schubert varieties defined by inclusions treated by Gasharov and Reiner.

This is joint work with Henning Ulfarsson (Reykjavik U.). (Received January 25, 2011)

16 ► Associative rings and algebras

1069-16-18 **Steven V Sam*** (ssam@math.mit.edu). *Symmetric quivers, invariant theory, and saturation theorems for the classical groups.*

Motivated by extending analogues of the saturation theorem of Knutson-Tao for the Littlewood-Richardson coefficients, and the proof of this theorem given by Derksen-Weyman, we study the semi-invariants of representation varieties of some algebras of global dimension 2 related to symmetric quivers. In this talk, I will introduce symmetric quivers and the statement of the saturation theorems and explain the connection. (Received November 20, 2010)

1069-16-28 **Miodrag C Iovanov*** (yovanov@gmail.com). *Generalized Frobenius algebras, algebraic integral theory and applications to representation theory, Hopf algebras and compact groups.*

The category of finite dimensional representations of any algebra, and that of all their colimits, can be seen as the category of finite dimensional and respectively arbitrary comodules over a suitable coalgebra. We use the more general language of coalgebras to give generalizations to the case of infinite dimensional topological and non-topological algebras of important algebra concepts, such as Frobenius and quasi-Frobenius algebras. These generalizations will unify several existing notions in algebra and in coalgebra theory, and we show their relevance and consequences for the representation theory of algebras and also for a very important class of Hopf algebras: those having a non-zero integral, which naturally generalize the algebra of functions on a compact group. Fundamental results, such as the existence and uniqueness of integrals of Hopf algebras can be obtained in the more general setting of coalgebras without any algebra structure present, with the aid of an integral

functor. This functor has a very concrete interpretation in the case of compact groups as quantum-invariant integrals. We will also present large classes of examples coming from graphs, but which will show connections of the concepts with category theory, homological algebra and even algebraic topology. (Received November 30, 2010)

1069-16-37 **Jose A. Velez Marulanda*** (javelezmarulanda@valdosta.edu), Department of Mathematics & Computer Science, Valdosta State University, 2072 Nevins Hall 1500 N. Patterson St, Valdosta, GA 31698, and **Frauke M. Bleher** (fbleher@math.uiowa.edu), Department of Mathematics, University of Iowa, 14 MacLean Hall, Iowa City, IA 52242. *Universal Deformation Rings of Modules over Frobenius Algebras.* Preliminary report.

Let k be a field of arbitrary characteristic, let Λ be a finite dimensional k-algebra and let V be a Λ-module with stable endomorphism ring isomorphic to k. Assuming that Λ is a self-injective algebra, we show that V has a universal deformation ring, denoted by $R(\Lambda, V)$, which is a complete local commutative Noetherian k-algebra with residue field k. Assuming that Λ is also a Frobenius algebra, we show that $R(\Lambda, V)$ is stable under syzygies. Then we turn to a particular Frobenius k-algebra Λ_0 and present the Λ_0-modules V with stable endomorphism ring isomorphic to k and their corresponding universal deformation rings $R(\Lambda_0, V)$. (Received December 10, 2010)

1069-16-51 **Shiping Liu*** (shiping.liu@usherbrooke.ca), Department of Mathématics, The University of Sherbrooke, Sherbrooke, Quebec J1K 2R1, Canada. *The derived category of an algebra with radical squared zero.* Preliminary report.

This is a joint work with Raymundo Bautista. Let A be a finite-dimensional algebra with radical squared zero, whose ordinary quiver is written as Q_A. Our purpose is to study the bounded derived category $D^b(A)$ of A. Using the technique of covering and the Koszul duality, we are able to relate $D^b(A)$ to the category of finitely co-presented representations of some covering of Q_A. We shall give a complete list of indecomposable objects in $D^b(A)$. This will enable us to determine easily the derived type of A in terms of Q_A. In case A is of finite global dimension, we shall give a complete description of the Auslander-Reiten components of $D^b(A)$. (Received January 05, 2011)

1069-16-62 **Ibrahim Assem**, Universite Sherbrooke, Quebec , Canada, **Vasilisa Shramchenko**, Universite Sherbrooke, Quebec , Canada, and **Ralf Schiffler*** (schiffler@math.uconn.edu), Department of Mathematics, 196 Auditorium Road, University of Connecticut, U-3009, Storrs, CT 06269-3009. *Cluster automorphisms.*

This talk is on a joint work with Assem and Shramchenko, in which we introduce and study cluster automorphisms of cluster algebras. These are automorphisms of the algebra which preserve the combinatorial cluster algebra structure. We compute the group of cluster automorphisms for Dynkin and Euclidean types using cluster categories and Riemann surfaces with marked points. (Received January 11, 2011)

1069-16-76 **Xueqing Chen*** (chenx@uww.edu), 800 West Main Street, Dept of Mathematical & Computer Sciences, University of Wisconsin–Whitewater, Whitewater, WI 53190. *Hall algebras over triangulated categories.*

Through the Ringel-Hall algebra approach, one can construct Kac-Moody Lie algebras and some elliptic Lie algebras from the derived categories of some finite dimensional associative algebras. In this talk, we start by recalling Peng-Xiao's work on the construction of Kac-Moody algebras from the derived categories of Hereditary algebras, Lin-Peng's work on the construction of some elliptic algebras from the derived categories of some tubular algebras, and Toen's work on the construction of derived Hall algebras over differential graded category under some finiteness conditions. Then we discuss some generalizations of the above results and prove an analogue of Toen's formula which is used to define derived Hall algebras for odd-periodic triangulated categories. As an example, the Hall algebra over the 3-periodic orbit triangulated category of a hereditary abelian category will be described. This talk is based on a joint work with F. Xu. (Received January 13, 2011)

1069-16-87 **Victor Camillo** and **Alexander Diesl*** (adiesl@wellesley.edu). *Sums of Units and Idempotents.* Preliminary report.

Fitting's lemma for finite matrix rings over fields asserts that every linear transformation is a sum of a unit and an idempotent. In general, rings satisfying the previous criteria are called clean rings. There have been many papers written on clean rings in the previous decade. We present results and problems of perhaps interest to representation theorists. In particular is clean a morita invariant. Also subtle combinatorial questions arise about the ways in which ring elements can be decomposed into sums of units and idempotents. (Received January 14, 2011)

1069-16-101 **Jon Carlson** and **Sunil Kumar Chebolu*** (schebol@ilstu.edu), Department of Mathematics, Illinois State University, Campus Box 4520, Normal, IL 61790, and **Jan Minac**. *A strong generating hypothesis for the stable module category.*

Let G be a finite p-group and let k be a field of characteristic p. A kG-linear map between kG-modules is called a strong ghost map if it induces the zero map in Tate cohomology when restricted to each subgroup of G. We formulate the strong generating hypothesis as the statement that every strong ghost between finitely generated kG-modules factors through a projective module, i.e., it is trivial in the stable module category. In joint work with Jon Carlson and Jan Minac, we have identified the class of p-groups for which this strong generating hypothesis holds. I will present an overview of this work and also our motivation for studying this problem. (Received January 17, 2011)

1069-16-102 **Alex Martsinkovsky*** (alexmart@neu.edu). *Suspended simples and projective resolutions.*

By a suspended simple we understand a simple module which cannot be embedded in the socle of the ring. Assuming the ring is semiperfect, we establish a new necessary condition for a syzygy module in a minimal projective resolution of a left module to have a projective summand: such a summand must be a direct sum of the principal projectives corresponding to the suspended simples. In particular, if the ring has no suspended simples, any module of finite projective dimension must be projective. The key in proving this result for left (resp., right) modules is the behavior of 1-torsion of right (resp., left) modules. This result indicates the importance of the asymptotic behavior of 1-torsion. (Received January 17, 2011)

1069-16-135 **F. Bleher**, **J. Froelich** and **G. Llosent*** (gllosent@csusb.edu). *Stable Endomorphism Rings for Modules that belong to Dihedral Blocks with two Simple Modules.*

Let k be an algebraically closed field of characteristic 2. Suppose G is a finite group and B is a block of kG with a diehedral defect group D such that there are precisely two isomorphism classes of simple B-modules. In this presentation we go over the process for determining all finitely generated kG-modules V which belong to B and whose stable endomorphism ring is isomorphic to k. The motivation for finding such modules is that the universal deformation ring $R(G, V)$ of V exists and is isomorphic to a subquotient ring of the group ring WD, where W is the ring of infinite Witt vectors over k. (Received January 20, 2011)

1069-16-142 **Alex Dugas*** (adugas@pacific.edu), Department of Mathematics, University of the Pacific, 3601 Pacific Ave, Stockton, CA 95211. *Periodic algebras arising as endomorphism rings.*

It is well-known that any maximal Cohen-Macaulay module over a hypersurface has a periodic free resolution of period 2. Auslander, Reiten and Buchweitz have used this periodicity to explain the existence of periodic projective resolutions for the finite-dimensional preprojective algebras of Dynkin type, which arise as stable endomorphism rings of Cohen-Macaulay modules. These algebras are in fact periodic, meaning that they have periodic projective resolutions as bimodules and thus periodic Hochschild cohomology as well. In this talk we give a generalization of this construction of periodic algebras in the context of Iyama's higher AR-theory. In particular, we study the endomorphism rings of periodic d-cluster tilting objects in triangulated categories. (Received January 20, 2011)

1069-16-151 **Ellen E. Kirkman***, Dept. of Mathematics, Box 7388, Wake Forest University, Winston-Salem, NC 27109, **James J.. Kuzmanovich**, Wake Forest University, and **James J Zhang**, University of Washington. *Invariants of AS-Regular Algebras: Complete Intersections.*

Let G be a finite group acting on an Artin-Schelter regular $\mathbb{C}$-algebra A. Extending results of Watanabe we give conditions when the invariant subring A^G is an Artin-Schelter Gorenstein algebra. When $A = \mathbb{C}[x_1, \cdots, x_n]$ Gordeev (1986) and Nakajima (1984) independently determined when A^G is a complete intersection. We discuss extending these results to other Artin-Schelter regular algebras. (Received January 21, 2011)

1069-16-159 **Frauke M. Bleher**, **Giovanna Llosent** and **Jennifer B. Schaefer*** (schaefje@dickinson.edu). *Universal Deformation Rings and Dihedral Blocks with Two Simple Modules.*

Let k be an algebraically closed field of characteristic 2, and let W be the ring of infinite Witt vectors over k. Suppose G is a finite group and B is a block of kG with dihedral defect group D such that there are precisely two isomorphism classes of simple B-modules. In this talk, we will determine the universal deformation ring $R(G, V)$ for a selection of finitely generated kG-modules V which belong to B and whose stable endomorphism ring is isomorphic to k. (Received January 21, 2011)

1069-16-262 **Ryan Kinser*** (ryan.kinser@uconn.edu). *Small tree modules for quivers with one vertex.* Preliminary report.

We will discuss some tools for studying indecomposable tree modules of small dimension d, having in mind the quiver S_m with one vertex and m loops as our main focus.

Utilizing some computations of Le Bruyn, we show that for $d \leq 5$ and any m, the number of dimension d tree modules for S_m is equal to $ai_{m,d}(1)$, where $ai_{m,d}(q)$ is the polynomial in q counting isomorphism classes of (absolutely) indecomposable representations of dimension d over the field with q elements. (The number $ai_{m,d}(1)$ is also the Euler characteristic of the moduli space of indecomposable complex representations of dimension d.)

The computations quickly become difficult as d grows, so for $d > 5$ it is not known if it is still true. We end with some other examples where this phenomenon is exhibited, and speculate on the relation of these observations to a conjecture of Kac. (Received January 24, 2011)

1069-16-263 **Yi-Lin Cheng*** (ylincheng@gmail.com), Department of Mathematics, Austin Peay State University, 601 College St., Clarksville, TN 37044, and **Siu-Hung Ng** (rng@iastate.edu), Department of Mathematics, Iowa State University, Carver Hall, Ames, IA 50011. *On Hopf algebras of dimension 4p.*

We consider the classification of Hopf algebras of dimension pq^2 over an algebraically closed field where p, q are distinct primes. In this talk, we will show a non-semisimple Hopf algebra H of dimension $4p$ with p an odd prime is pointed if H contains more than two group-like elements. We also give the complete classification for non-semisimple Hopf algebras of dimension 20,28 and 44. (Received January 24, 2011)

1069-16-276 **Milen Yakimov*** (yakimov@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Open Richardson varieties in Poisson geometry and ring theory.*

We will describe how Lusztig's stratifications of partial flag varieties and open Richardson varieties appear in the framework of Poisson geometry. This combinatorial and geometric framework will then be used to classify the spectra of De Concini-Kac-Procesi algebras and quantum flag varieties. (Received January 24, 2011)

1069-16-327 **Andrew T. Carroll*** (andrewcarroll.neu@gmail.com), 54 Melrose Street, Apt. 1, Boston, MA 02116. *Generic Modules over Gentle String Algebras.*

Let kQ/I be a gentle string algebra such that Q has neither loops nor oriented cycles. We will show that $SI(\mathrm{Rep}_{kQ/I}(\beta)_r)$, the ring of semi-invariant functions on each component $\mathrm{Rep}_{kQ/I}(\beta)_r$ is a semi-group ring. We also exhibit generators for the underlying semi-group, which allows us to give an upper bound on the degrees of the generators for the rings of semi-invariants. (Received January 25, 2011)

1069-16-332 **Andrew Carroll** and **Jerzy M Weyman*** (j.weyman@neu.edu). *Generic modules for string algebras.* Preliminary report.

I will discuss the description of the generic modules in the irreducible components of representation spaces of colored string algebras. This class of algebras was defined by the authors to study the rings of semi-invariants of this class of algebras. Using the theorem of Crawley-Boevey and Schroer we can describe the generic modules in combinatorial terms.

The construction was carried out by the second author (in collaboration with Kraskiewicz) for a special class of string algebras of non-polynomial growth, and by the first author in general. (Received January 25, 2011)

1069-16-341 **Markus Schmidmeier*** (markus@math.fau.edu). *Invariant subspaces of linear operators: Symmetry properties via poset representations.*

There has been a lot of recent interest in categories of systems consisting of a linear operator and one or several invariant subspaces, they occur for example in the work of D. Simson, D. Kussin, H. Lenzing, H. Meltzer, X.-W. Chen, P. Zhang e.a. Categories of systems play a role in various places in pure and applied mathematics — in fact, wherever linear operators and invariant subspaces come up — in particular there are links to coherent sheaves over weighted projected lines, to singularity theory, and to control theory.

In this talk about joint work with C. M. Ringel, we will see that classical representation theory of partially ordered sets provides efficient ways of dealing with linear operators. Remarkable symmetries of categories of systems can be realized by symmetries of the underlying poset. (Received January 25, 2011)

1069-16-345 **Harm Derksen*** (hderksen@umich.edu). *Counting Subrepresentations of Quiver Representations.*

For many applications, such as cluster algebras, and Schubert Calculus, one has to study quiver Grassmannians. I will discuss various results about quiver Grassmannians and how they can be used to solve problems in other areas. (Received January 25, 2011)

18 ► Category theory; homological algebra

1069-18-112 **Kiyoshi Igusa*** (igusa@brandeis.edu), Mathematics Department, Brandeis University, 415 South St., Waltham, MA 02454, and **Gordana G Todorov** (todorov@neu.edu), Mathematics Department, Northeastern University, 360 Huntington Ave, Boston, MA 02115. *Continuous Cluster Category.* Preliminary report.

We construct a continuous cluster category isomorphic to a limit of finite spaced-out cluster categories and study its basic properties. This continuous cluster category is a K-category which is homogeneous and triangulated by construction and the isomorphism classes of indecomposable modules are in bijection with the points on the open Moebius band. By homogeneous we mean that there are triangulated automorphisms of the category which carry one indecomposable object to any other. So, they are essentially all the same.

The triangulated structure comes from the fact that this category is an orbit category of a quotient of an exact category having a structure similar to a Frobenius category. Distinguished triangles can be interpreted as immersed ideal polyhedra in the hyperbolic plane with carefully chosen coefficients (elements of the ground field) at crossings of sides and ideal vertices. Clusters in the category are defined to be maximal discrete sets of pairwise compatible indecomposable objects.

We use the algebra of the exact category, the topology of the Moebius band and the geometry of the hyperbolic plane to give descriptions of the distinguished triangles. We also discuss the relation to the unbounded cluster category for once punctured surfaces. (Received January 23, 2011)

1069-18-225 **Bethany Kubik*** (bethany.kubik@ndsu.edu), NDSU Mathematics Dept #2750, PO Box 6050, Fargo, ND 58108-6050, **Micah J Leamer** (s-mleamer1@math.unl.edu), University of Nebraska-Lincoln, Department of Mathematics, 232 Avery Hall, Lincoln, NE 68588-0130, and **Sean Sather-Wagstaff** (sean.sather-wagstaff@ndsu.edu), NDSU Mathematics Dept #2750, PO Box 6050, Fargo, ND 58108-6050. *Properties of Ext for non-noetherian modules.* Preliminary report.

Let R be a local ring and let M and M' be R-modules. If M and M' are noetherian, then the module $\mathrm{Ext}^i_R(M, M')$ is noetherian for all $i \geq 0$. If M is noetherian and M' is artinian, then $\mathrm{Ext}^i_R(M, M')$ is artinian for all $i \geq 0$. We describe some properties of $\mathrm{Ext}^i_R(M, -)$ when M is artinian, and more generally when M is mini-max, that is, when M has a noetherian submodule N such that M/N is artinian. (Received January 24, 2011)

1069-18-252 **Tom Howard*** (thoward@math.ucsb.edu). *Complexity as a homological invariant.*

Let M be a finite dimensional module over a finite dimensional algebra A. The complexity of M measures the extent to which M fails to have finite projective dimension by recording the rate at which terms in a minimal projective resolution grow. Three questions arise. 1) How can we compute complexity? 2) Which values of complexity can occur? 3) What good is knowing complexities? (Received January 24, 2011)

1069-18-257 **Radmila Sazdanovic*** (radmilas@sas.upenn.edu), Department of Mathematics, University of Pennsylvania, David Rittenhouse Lab 209 South 33rd Street, Philadelphia, PA 19104-6395, and **Mikhail Khovanov**. *Categorification of the polynomial ring Z[x].*

We introduce a categorification of the one-variable polynomial ring Z[x], based on the geometrically defined graded algebra and show how to lift various operations on polynomials to the categorified setting. (Received January 24, 2011)

19 ► K-theory

1069-19-34 **Ayelet Lindenstrauss*** (alindens@indiana.edu), Department of Mathematics, Indiana University, Bloomington, IN 47401, and **Randy McCarthy**. *The Algebraic K-theory of Formal Power Series.*

We study the algebraic K-theory of parametrized endomorphisms of a unital ring R with coefficients in a simplicial R-bimodule M, and compare it with the algebraic K-theory of the ring $T^{\pi}_{R}(M)$ of formal power series in M over R. Waldhausen defined an equivalence $\Sigma\tilde{K}(\mathrm{Nil(R;M)}) \to \tilde{K}(T_R(M))$. Extending Waldhausen's map from nilpotent endomorphisms to all endomorphisms, we define a natural transformation of functors of simplicial R-bimodules $\Sigma\tilde{K}(R;M) \to \tilde{K}(T^{\pi}_{R}(M))$ which has to land in the ring of formal power series rather than in the tensor algebra for convergence reasons, and is no longer in general an equivalence (it is an equivalence when the bimodule is connected). Nevertheless, the map shows a close connection between its source and its target: it induces an equivalence on the Goodwillie Taylor towers of the two (as functors of M, with R fixed), and allows us to give a formula for the suspension of the invariant $W(R;M)$ (which can be thought of as Witt vectors with coefficients in M, and is what the Goodwillie Taylor tower of the source functor converges to), $\Sigma W(R;M) \simeq \mathrm{holim}_n \tilde{K}(T_R(M)/(M)^{n+1})$. (Received January 21, 2011)

1069-19-70 **Bruce A Magurn*** (magurnba@muohio.edu), Department of Mathematics, Miami University, Oxford, OH 45056. *Negative K-theory of generalized quaternion groups and binary polyhedral groups.*

Classical group representation theory is used to show the finite groups that have finite negative K-theory are those groups with every element of prime power order. There follows a computation of the K_{-1} of integral group rings $\mathbb{Z}G$ for all finite non-abelian subgroups of the group $SU(2)$ of unit quaternions. In principle, the method applies to any finite group. (Received January 13, 2011)

1069-19-175 **Inna I Zakharevich*** (zakh@math.mit.edu). *Scissors Congruence as K-theory.*

The basic question of scissors congruence is as follows: given two polytopes in Euclidean space, when is it possible to dissect one into pieces and rearrange them to form the second? By defining an n-simplex to be the convex hull of $n+1$ points we can generalize this question to geometries other than Euclidean space. Traditionally, these questions were approached by rephrasing them in terms of group homology of Lie groups made discrete, but this line of inquiry also resulted in tantalizing connections to algebraic K-theory.

More specifically, the 3-dimensional scissors congruence groups for Euclidean space, spherical space, and hyperbolic space all admit a Dehn invariant, whose target group is $\mathbf{R} \otimes_{\mathbf{Z}} \mathbf{R}/\mathbf{Z}$. This group contains the decomposable part of $K_2(\mathbf{C})^-$ as a subquotient, and in fact the hyperbolic scissors congruence groups can be placed into a long exact sequence with the groups $K_2(\mathbf{C})^-$ and $K_3(\mathbf{C})^-$.

Dupont and Sah obtain this relation by an explicit calculation via generators and relations. In this talk we will go back to the foundations of the subject, rephrasing them in terms of algebraic K-theory in hopes of finding a more direct proof of this result. (Received January 22, 2011)

1069-19-199 **Clark Barwick***, Department of Mathematics, Massachusetts Institute of Technology 2-263, 77 Massachusetts Avenue, Cambridge, MA 02139-4307. *Higher algebraic K-theory of ∞-categories.* Preliminary report.

In joint work with John Rognes, we show how to transfer the technologies and results of Quillen and Waldhausen in higher algebraic K-theory to the context of ∞-categories. Analogues of the $S_\bullet$- and Q-constructions — as well as versions of the additivity, localization, and dévissage theorems — are among the results we find in this new context. As a motivation for this work, we discuss a conjecture of Hopkins, Waldhausen, and Rognes on the algebraic K-theory of $\mathrm{BP}\langle n\rangle$. (Received January 23, 2011)

1069-19-206 **Jeremiah Heller*** (heller@math.northwestern.edu) and **Jose Malagón-López**. *Equivariant Algebraic Cobordism (pt. 2).*

In a continuation of J. Malagón-López' talk we further discuss equivariant algebraic cobordism of algebraic varieties with an action of a linear algebraic group. We focus on some basic examples of computations and properties of this theory useful for further computations. (Received January 23, 2011)

1069-19-272 **Vigleik Angeltveit*** (vigleik@math.uchicago.edu), **Teena Gerhardt**, **Michael Hill** and **Ayelet Lindenstrauss**. *Cyclotomic spectra and K-theory of truncated polynomial algebras.* Preliminary report.

We study the algebraic K-theory of a truncated polynomial algebra of the form $A = k[x_1, \ldots, x_n]/(x_i^{a_i})$ by using the cyclotomic trace map from algebraic K-theory to topological cyclic homology. Topological cyclic homology is

constructed from topological Hochschild homology, and the main innovation is to write the topological Hochschild homology spectrum $THH(A)$ as the iterated homotopy pushout of an n-cube of *cyclotomic spectra*. It follows that topological cyclic homology of A is the iterated pushout of a corresponding n-cube, where each term can be evaluated easily. In particular this determines the algebraic K-theory of $\mathbb{F}_p[x_1, \ldots, x_n]/(x_i^{a_i})$ whenever p does not divide any of the a_i. (Received January 24, 2011)

1069-19-338 **Andrew J. Blumberg***, Department of Mathematics, University of Texas, Austin, TX 78712, and **Michael A. Mandell**, Department of Mathematics, Rawles Hall, 831 E. 3rd Street, Bloomington, IN 47405. *Derived Koszul duality and the algebraic K-theory of spaces.*

For a finite complex X, we can associate two natural ring spectra: the "group ring" on the based loop space $\Sigma^\infty_+(\Omega X)$ and the Spanier-Whitehead dual $DX = F_S(\Sigma^\infty_+ X, S)$. In this talk I will discuss some recent work on K-theoretic invariants of the associated module categories. (Received January 25, 2011)

20 ► Group theory and generalizations

1069-20-144 **Jon F. Carlson*** (jfc@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602, and **Dan Nakano**, Department of Mathematics, University of Georgia, Athens, GA 30602. *Endotrivial modules for finite group schemes.* Preliminary report.

It is well known that if G is a finite group then the group of endotrivial modules is finitely generated. In this paper we prove for an arbitrary finite group scheme G that for any fixed integer $n \geq 0$ there are only finitely many non-isomorphic endotrivial modules of dimension n. This provides evidence that the group of endotrivial modules for a finite group scheme is finitely generated. Applications and connections are also provided in terms lifting and twisting the structure of endotrivial modules. (Received January 20, 2011)

1069-20-162 **Persi Diaconis**, **I. Martin Isaacs** and **Nathaniel Thiem*** (thiemn@colorado.edu). *Understanding random walks with supercharacters.*

When viewed as a non-commutative analogue to Fourier analysis, it is natural to use character theory to study random walks on groups. However, there are plenty of groups whose character theory is provably wild, such as the group of unipotent upper-triangular matrices over a finite field. To be able to still study these groups, Andre and later Diaconis–Isaacs developed a way to approximate a character theory into a supercharacter theory. This talk describes some of the features of a supercharacter theory and how it can give insights to some known random walks. (Received January 21, 2011)

1069-20-163 **Jason Shaw*** (jshaw10@stmarytx.edu), Department of Mathematics, One Camino Santa Maria, San Antonio, TX 78228. *Commutator relations and the clones of finite groups.*

Let G be a group, and let $\mathrm{Clo}(G)$ denote the clone of G. We want to examine the following question: Does there exist an integer $k > 0$ such that for *all* groups G the clone of G is determined by the subgroups of G^k? By 'determined' we mean that an operation $f \in \mathrm{Clo}(G)$ if and only if f preserves the subgroups of G^k. To examine this question the idea of a commutator relation for groups is extended to a higher order commutator relation for groups. We employ these higher order commutator relations for groups to study the clones of the dihedral 2-groups D_{2^n}, where n is an integer, $n \geq 3$. In so doing, we conclude that the smallest positive integer $k(n)$ such that $\mathrm{Clo}(D_{2^n})$ is determined by the subgroups of $(D_{2^n})^{k(n)}$ satisfies the inequality $n < k(n) \leq 2^{n-1}$, a number that grows without bound as $n \to \infty$. Hence, we are able to prove that there does not exist an integer $k > 0$ such that for all groups G the clone of G is determined by the subgroups of G^k.
(Received January 21, 2011)

1069-20-208 **Nicholas Teff*** (nicholas-teff@uiowa.edu), Department of Mathematics, 14 MacLean Hall, University of Iowa, Iowa City, IA 52242-1419. *Hessenberg Varieties, Bruhat Order and Young's Rule.*

We study a family of smooth algebraic varieties called regular semisimple Hessenberg varieties, that includes the flag variety and the toric variety associated to the Coxeter complex of type A. We show how to construct combinatorially the cohomology of regular semisimple Hessenberg varieties. This construction is purely in terms of the Bruhat order on the symmetric group, and lets us define a representation of the symmetric group on the cohomology. This representation generalizes the work of Procesi, Stembridge and Tymoczko. When the Hessenberg variety is of parabolic type, we give an explicit formula for the representation via Young's Rule, giving the multiplicity of the irreducible representations in terms of the Kostka numbers. (Received January 23, 2011)

1069-20-267 **Lawrence Morris*** (lmorris@clarku.edu), Worcester, MA 01610. *An application of Hecke algebras to principal series.* Preliminary report.

I shall use results from affine Hecke algebras to recover a result of Rodier on the decomposition of the regular principal series for a split reductive group defined over a non-archimedean local field. (Received January 24, 2011)

1069-20-277 **Zajj B Daugherty*** (daugherz@stolaf.edu), **Arun Ram** and **Rahbar Virk**. *The centers of the affine BMW algebra and its degenerate version.* Preliminary report.

The affine Birman-Murakami-Wenzl algebra arises both diagrammatically as an algebra of tangles in a punctured space, and algebraically via Schur-Weyl duality with the action of quantum groups of classical Lie type. Through exploring the structure of the affine BMW algebra and its degenerate version, we reveal that the center each algebra is generated by a nice family of symmetric functions. In particular the center of the degenerate affine BMW algebra is a ring that also arises in studying, for example, projective representation theory of the symmetric group, Chern numbers of kernel and cokernel bundles, and the homology of the loop space of the symplectic group. (Received January 24, 2011)

22 ► Topological groups, Lie groups

1069-22-94 **David C Manderscheid*** (dmanderscheid2@unl.edu), Dean, College of Arts and Sciences, 1223 Oldfather Hall, University of Nebraska-Lincoln, Lincoln, NE 68588. *Base Change and Theta-correspondences for Supercuspidal Representations of SL(2).*

In this talk I will explain a surprisingly simple method to use the theta-correspondences associated to the Shimura Correspondence to interpret quadratic base change for L-packets of supercuspidal representations of SL(2) as a theta-correspondence. The key to the method is to compare the theta-correspondences by explicitly realizing types for the representations in lattice models of the relevant Weil representations. (Received January 16, 2011)

1069-22-255 **Steven T Spallone***, sspallone@gmail.com, and **Freydoon Shahidi**. *Residues of Intertwining Operators for Classical Groups.*

Let $\tilde{G}$ be a symplectic or even orthogonal group over a p-adic field F, and M the Levi factor of a maximal parabolic subgroup of $\tilde{G}$. Suppose that M has the shape of three blocks of the same size. Let π be a supercuspidal representation of M. We discuss an expression for the residue of the standard intertwining operator for the parabolic induction of π from M to G. (Received January 24, 2011)

33 ► Special functions

1069-33-136 **Paul M Terwilliger***, Math Department, University of Wisconsin, 480 Lincoln Drive, Madison, WI 53706. *The Rahman polynomials and the Lie algebra* $\mathfrak{sl}_3(\mathbb{C})$.

We interpret the Rahman polynomials in terms of the Lie algebra $\mathfrak{sl}_3(\mathbb{C})$. Using the parameters of the polynomials we define two Cartan subalgebras for $\mathfrak{sl}_3(\mathbb{C})$, denoted H and $\tilde{H}$. We display an antiautomorphism $\dagger$ of $\mathfrak{sl}_3(\mathbb{C})$ that fixes each element of H and each element of $\tilde{H}$. We consider a certain finite-dimensional irreducible $\mathfrak{sl}_3(\mathbb{C})$-module V consisting of homogeneous polynomials in three variables. We display a nondegenerate symmetric bilinear form $\langle\ ,\ \rangle$ on V such that $\langle \beta\xi, \zeta\rangle = \langle \xi, \beta^\dagger \zeta\rangle$ for all $\beta \in \mathfrak{sl}_3(\mathbb{C})$ and $\xi, \zeta \in V$. We display two bases for V; one diagonalizes H and the other diagonalizes $\tilde{H}$. Both bases are orthogonal with respect to $\langle\ ,\ \rangle$. We show that when $\langle\ ,\ \rangle$ is applied to a vector in each basis, the result is a trivial factor times a Rahman polynomial evaluated at an appropriate argument. We also obtain two seven-term recurrence relations satisfied by the Rahman polynomials. This is joint work with Plamen Iliev. (Received January 20, 2011)

34 ► Ordinary differential equations

1069-34-40 **Charles Lamb*** (clamb@math.ku.edu) and **Erik Van Vleck**. *Neutral Equations of Mixed Type.* Preliminary report.

We extend the linear Fredholm theory for mixed type functional differential equations (with both advances and delays) to neutral equations of mixed type. We consider a prototype problem of coupling between two nerve fibers in which a traveling wave assumption results in a system of neutral type equations. We employ the linear

theory developed and local continuation to show existence and investigate the stability of solutions for small values of the coupling parameter. (Received December 10, 2010)

35 ► Partial differential equations

1069-35-5 **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)

1069-35-26 **Sukjung Hwang*** (shwang@iastate.edu), 4329 Linclon Swing St. Unit 32, Ames, IA 50014. *The Holder continuity of solutions to the generalized p-Laplacian type of parabolic equation.* Preliminary report.

In 1986, DiBenedetto introduced the intrinsic scaling idea, which has been used to prove Hölder continuity of solutions of both degenerate and singular $p-$Laplacian elliptic and parabolic equations. Degenerate and singular equations have been studied separately mainly because of their different natures although there are regularity theories holding for both type of equations.

For elliptic equations, Lieberman provided a uniform proof for both degenerate and singular cases in 1991. A new proof of Hölder continuity for solutions of degenerate parabolic equations by Gianazza, Surnachev, and Vespri simplifies DiBenedetto's original proof by relying on strong geometry. We modify these arguments to obtain Hölder continuity of solutions for equations of the form

$$u_t - \operatorname{div}\left(g(|Du|)\frac{Du}{|Du|}\right) = 0,$$

where g is a continuous nonnegative increasing function with $g(0) = 0$ such that the antiderivative of g, say G, satisfies Δ_2 and ∇_2 conditions; that is, there exist some positive constants g_0 and g_1 such that $1 < g_0 \le g_1 < \infty$ and

$$g_0 G(a) \le a g(a) \le g_1 G(a) \quad \text{for} \quad a > 0.$$

(The standard $p-$Laplacian equation corresponds to $g(a) = a^{p-1}$.) (Received November 30, 2010)

1069-35-31 **Yuxi Zheng*** (yzheng1@yu.edu), Yeshiva University, 2495 Amsterdam Ave, New York, NY 10033. *Semi-hyperbolic patches of solutions to two-dimensional compressible Euler systems.*

We consider Riemann problems for the compressible Euler system in aerodynamics in two space dimensions. The solutions involve shock waves, hyperbolic and elliptic regions. There are also regions which we call semi-hyperbolic. We have shown before the existence of such solutions, and now we show regularity of the boundaries of such regions. (Received December 01, 2010)

1069-35-67 **Gary M. Lieberman*** (lieb@iastate.edu), IA , and **Xing-Bin Pan** (xbpan@math.ecnu.edu.cn). *On a quasilinear system arising in the theory of superconductivity.*

We prove that the solution of a quasilinear system involving the curl operator is globally $C^{2+\alpha}$. This regularity was previously proved by Bates and Pan assuming some strong restrictions on the topology of the domain and on the boundary data. In this paper, we obtain the regularity result by a careful study of a related quasilinear Neumann problem for a scalar elliptic equation. (Received January 12, 2011)

1069-35-69 **W. Y. Chan*** (wchan@semo.edu), Department of Mathematics MS6700, Southeast Missouri State University, Cape Girardeau, MO 63701. *Quenching behavior for nonlinear degenerate parabolic problems.*

In this paper, we study the nonlinear degenerate parabolic initial-boundary value problems: $u_\tau = \left(\xi^r u^m u_\xi\right)_\xi / \xi^r + f(u)$ for $0 < \xi < a$, $0 < \tau < \Lambda \le \infty$, $u(\xi, 0) = u_0(\xi)$ for $0 \le \xi \le a$, and $u(0, \tau) = 0 = u(a, \tau)$ for $0 < \tau < \Lambda$, where a and m are positive constants, r is a constant less than 1, $f(u)$ is a positive function such that $\lim_{u \to c-} f(u) = \infty$ for some positive constant c, and $u_0(\xi)$ is a given function satisfying $u_0(0) = 0 = u_0(a)$. In this paper, we study the quenching rate and quenching set of the solution. (Received January 13, 2011)

1069-35-77 **Gonzalo Alduncin*** (alduncin@geofisica.unam.mx), Instituto de Geofísica, UNAM, Cd. Universitaria, Coyoacán, 04510, D.F., 04510 , Mexico. *Composition Duality Methods for Quasistatic Evolution Elasto-Visco-Plastic Variational Problems.*

Composition Duality Methods for Quasistatic Evolution Elasto-Visco-Plastic Variational Problems

Gonzalo Alduncin

The purpose of this paper is to study quasistatic evolution elasto-visco-plastic variational problems. Considering solid bodies undergoing small strains and displacements,in the context of standard materials.

Here, we are concerned with the dual elasto-visco-plastic constitutive velocity-stress model, in conjunction with the quasistatic equilibrium equation and, in particular, with the bilateral Tresca contact constraint. In this manner, we are able to apply composition duality methods for dual evolution mixed analysis, as well as corresponding primal static mixed analysis, in the sense of the multivalued variational theories proposed in [1] and [2].

As applications, we present some representative elasto-visco-plastic constitutive models exemplifying the theory. Furthermore, we consider variational optimal control problems associated to the bilateral Tresca contact constraint.

1. Alduncin G (2007) Composition duality methods for evolution mixed variational inclusions. Nonlinear Analysis: Hybrid Systems 1: 336-363.

2. Alduncin G (2005) Composition duality methods for mixed variational inclusions. Applied Mathematics & Optimization 52: 311-348. (Received January 14, 2011)

1069-35-78 **Zhongwei Tang*** (tangzw@bnu.edu.cn), Xinjiekouwai Street, 19, Haidian, Beijing 100875, Peoples Rep of China. *Spike-layer Solutions to Singularly Perturbed Semilinear Systems of Coupled Schrödinger Equations.*

In present talk, we are concerned with the interaction and the configuration of spikes in a double condensate by analyzing the least energy solutions of two couple Schrödinger equations in a bounded domain.

We firstly proved the existence and noexistence of least energy solutions for the systens under Neumann and Dirichlet boundary conditions.

Secondly we studied the asypmtotic behavior of the least energy solutions as the parameter varepsilon goes to zero. (Received January 14, 2011)

1069-35-82 **Anna Ochal*** (ochal@ii.uj.edu.pl), Faculty of Mathematics and Computer Science, ul. Lojasiewicza 6, 30-348 Krakow, Poland. *Dynamic antiplane frictional contact problems - modeling and analysis.*

We consider a mathematical model which describes the antiplane shear deformation of a viscoelastic cylinder in frictional contact with a rigid foundation. The process is dynamic and friction is modeled with a multivalued boundary condition involving the Clarke subdifferential.

In antiplane shear of a cylindrical body, the displacement is parallel to the generators of the cylinder and is independent of the axial coordinate. Hence the governing equations and boundary conditions for antiplane shear problems are simple and have the virtue of relative mathematical simplicity without loss of essential physical relevance.

A variational formulation of the problem leads to an evolutionary hemivariational inequality of second order for the displacement field. We prove the existence of a weak solution to the model. The proof is based on arguments of abstract second order evolutionary inclusions with monotone operators in Banach spaces. We prove that under additional assumptions the weak solution is unique.

We give some examples of friction laws for which our results are valid. We only remark the antiplane version of the slip or slip rate dependent Coulomb law of dry friction, as well the nonmonotone or mulivalued friction laws which lead to considered boundary conditions. (Received January 14, 2011)

1069-35-95 **Ronghua Pan*** (panrh@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, 686 Cherry Street, Atlanta, GA 30084. *Vanishing viscosity limit for isentropic compressible fluids.*

We review some recent progress made on the vanishing viscosity limit from compressible Navier-Stokes equations to Euler equations in one space dimension. (Received January 16, 2011)

1069-35-96 **Daomin Cao** (dmcao@amt.ac.cn), Institute of Applied Mathematics, Chinese Academy of Sciences, Beijing, Beijing 100190, Peoples Rep of China, **Shuangjie Peng***, School of Mathematics and Statistics, Central China Normal University, Wuhan, Hubei 430079, Peoples Rep of China, and **Shusen Yan**, Department of Mathematics, The University of New England, Armidale, NSW 2315, Australia. *Multiplicity of solutions for the plasma problem in two dimensions.*

Let Ω be a bounded domain in $R^2, u_+ = u$ if $u \geq 0$, $u_+ = 0$ if $u < 0$, $u_- = u_+ - u$. In this talk we study the existence of solutions to the following problem arising in the study of a simple model of a confined plasma

$$(P_\lambda) \qquad \begin{cases} \Delta u - \lambda u_- = 0, & \text{in } \Omega, \\ u = c, & \text{on } \partial\Omega, \\ \int_{\partial\Omega} \frac{\partial u}{\partial \nu}\, ds = I, \end{cases}$$

where ν is the outward unit normal of $\partial\Omega$ at x, c is a constant which is unprescribed, and I is a given positive constant. The set $\Omega_p = \{x \in \Omega,\ u(x) < 0\}$ is called plasma set. Existence of solutions whose plasma set consisting of one component and asymptotic behavior of plasma set were studied by Caffarelli and Friedman for large λ. Under the condition that the homology of Ω is nontrivial we obtain in this paper by a constructive way that for any given integer $k \geq 1$, there is $\lambda_k > 0$ such that for $\lambda > \lambda_k$, (P_λ) has a solution with plasma set consisting of k components. (Received January 16, 2011)

1069-35-105 **Tong Li** (tli@math.uiowa.edu), Department of Mathematics, 15 McLean Hall, The University of Iowa, Iowa City, IA 52242-1419, and **Kun Zhao*** (kzhao@mbi.osu.edu), 1735 Neil Ave, 381 Jennings Hall, The Ohio State University, Columbus, OH 43210. *Global existence and long-time behavior of smooth solutions and entropy weak solutions to a quasilinear hyperbolic blood flow model.*

This talk is concerned about an initial-boundary value problem for a one-dimensional quasilinear hyperbolic model of blood flow with viscous damping. First, it is shown that for given smooth initial data close to a constant equilibrium state, there exists a unique global smooth solution to the model and the solution converges to the constant equilibrium state exponentially fast as time goes to infinity due to viscous damping and boundary effects. Second, it is shown that L^∞ entropy weak solutions exist globally in time when the initial data is large, rough and contains vacuum state. Furthermore, based on entropy principle and the theory of divergence measure field, it is shown that any L^∞ entropy weak solution converges to a constant equilibrium state exponentially fast as time goes to infinity. (Received January 17, 2011)

1069-35-114 **Francois Hamel*** (francois.hamel@univ-cezanne.fr), Universite d'Aix-Marseille, Faculte des Sciences et Techniques, LATP, Avenue Escadrille Normandie-Niemen, 13397 Marseille, France. *Spreading speeds of solutions of reaction-diffusion equations.*

A fundamental aspect which accounted for the success of reaction-diffusion models is related to the description of spreading phenomena at large time in unbounded domains. Estimating the spreading speeds is one of the most important issues from a theoretical point of view as well as for the applications in biology and ecology. Usually, the solutions spread at a finite speed which is uniquely determined from the initial data. In this talk, I will report on some recent results obtained in colloboration with G. Nadin, L. Roques and Y. Sire which show that, even for the simplest reaction-diffusion models, spreading with a finite and uniquely determined speed may fail. Examples of propagation with an infinite speed and complex situations with non-trivial intervals of spreading speeds will be discussed. (Received January 18, 2011)

1069-35-115 **yinbin deng*** (ybdeng@mail.ccnu.edu.cn), Department of Mathematics, Huazhong Normal University, Wuhan, Hubei 430079, Peoples Rep of China, **yi li** (yi-li@uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52242-141, and **fen yang**. *On the positive radial solutions of a class of singular semilinear elliptic equations.* Preliminary report.

In this paper, we consider the following elliptic equation

$$div(A(|x|)\nabla u) + B(|x|)u^p = 0 \qquad \text{in } R^n, \tag{0.1}$$

where $p > 1$, $n \geq 3$, $A(|x|) > 0$ is differentiable in $R \setminus \{0\}$ and $B(|x|)$ is a given nonnegative Hölder continuous function in $R \setminus \{0\}$. The asymptotic behavior at infinity and structure of separation property of positive radial solutions with different initial data for (0.1) are discussed. Moreover, the existence and separation property of infinitely many positive solutions for Hardy equation and an equation related to Caffarelli-Kohn-Nirenberg inequality are obtained respectively, as special cases. (Received January 18, 2011)

1069-35-116 **Dongsheng Li*** (lidsh@mail.xjtu.edu.cn), College of Science, Xi'an Jiaotong University, X'an, Shaanxi 710049, Peoples Rep of China, and **Lihe Wang** (lwang@math.uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA IA 52242. *L^p estimates of Stokes equations.*

In this paper, we will discuss L^p estimates of Stokes equations. Both local and global L^p estimates are given. We generalize the well known results. Our proof is a knid of geometric approach. (Received January 19, 2011)

1069-35-124 **Eitan Tadmor** and **Dongming Wei*** (dwei@math.wisc.edu), 480 Lincoln Dr, Madison, WI 53706. *A variational formula for the weak solutions of pressureless Euler-Poisson equations.*

We derive an explicit representation formula for global weak solutions of the one dimensional system of pressureless Euler-Poisson equations. This is an extension of the well-known formula for entropy solutions of the scalar inviscid Burgers' equation: since the characteristics of the Euler-Poisson equations are parabolas, our representation of their solution takes the form of a "quadratic" version of the celebrated Lax-Oleinik variational formula. We further extended this result to the multi-dimensional weighted Euler/Euler-Poisson system with symmetry. (Received January 19, 2011)

1069-35-128 **Zhengce Zhang*** (zhangzc@mail.xjtu.edu.cn), College of Science, Xi'an Jiaotong University, Xi'an, Shaanxi , Peoples Rep of China, and **Bei Hu** (b1hu@nd.edu), Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556. *Gradient blowup rate for a semilinear parabolic equation.*

We present a one-dimensional semilinear parabolic equation $u_t = u_{xx} + x^m|u_x|^p, p > 0, m \geq 0$, for which the spatial derivative of solutions becomes unbounded in finite time while the solutions themselves remain bounded. This phenomenon is called gradient blowup. It is a simple example of a parabolic PDE with a nonlinearity depending on the first order spatial derivatives of u. Generally, the equation $u_t - \epsilon\Delta u = f(x, \nabla u)$ may be viewed as the viscosity approximation (as $\epsilon \to 0^+$) of Hamilton-Jacobi type equations from stochastic control theory. On the other hand, the equation appears in the physical theory of growth and roughening of surfaces, where it is known as the Kardar-Parisi-Zhang equation. We show that the spatial derivative of solutions is globally bounded in the case $p \leq m + 2$ while blowup occurs at the boundary when $p > m + 2$. Blowup rate is also found for some range of p. It is shown that the gradient blowup rate will never match that of the self-similar variables which is called non-self-similar blowup. The main difficulty is to get the gradient blowup rate upper bound. The result is a joint work with Prof. Bei Hu. (Received January 19, 2011)

1069-35-134 **Sergey Denisov*** (denissov@math.wisc.edu), University of Wisconsin-Madison, Department of Mathematics, 480 Lincoln Dr., Madison, WI 53706. *Wave equation with slowly decaying potential: asymptotics and wave operators.*

For the one-dimensional wave equation, we address the following question: what are the minimal assumptions on the potential that guarantee propagation of the wave? It turns out that this condition is square summability of potential and this result is sharp. (Received January 20, 2011)

1069-35-164 **Alejandro Vélez-Santiago*** (alejovelez32@gmail.com). *Quasi-linear parabolic equations with nonlocal Robin boundary conditions.*

Let $p \in [2N/(N+2), N) \cap (1, N)$, and let $\Omega \subseteq \mathbb{R}^N$ be a bounded domains whose boundary is an upper d-set with respect to a Borel regular measure μ, for some $d \in (N - p, N)$. We show that a realization of the p-Laplacian with nonlocal Robin boundary conditions generates a (nonlinear) submarkovian C_0-semigroup on $L^2(\Omega, dx)$, and hence, the associated first order Cauchy problem is well-posed on $L^q(\Omega, dx)$ for every $q \in [1, \infty)$. (Received January 21, 2011)

1069-35-177 **Hailing Liu** and **Jaemin Shin*** (shin@ima.umn.edu). *The Cauchy-Dirichlet problem for the FENE dumbbell model of polymeric fluids.*

The FENE dumbbell model consists of the incompressible Navier-Stokes equation and the Fokker-Planck equation for the polymer distribution. In such a model, the polymer elongation cannot exceed a limit $\sqrt{b}$, yielding all interesting features near the boundary. In this talk, we present the local well-posedness for the FENE dumbbell model under a class of Dirichlet-type boundary conditions dictated by the parameter b. As a result, for each $b > 0$ we identify a sharp boundary requirement for the underlying density distribution, while the sharpness follows from the existence result for each specification of the boundary behavior. It is shown that the probability density governed by the Fokker-Planck equation approaches zero near boundary, necessarily faster than the distance function d for $b > 2$, faster than $d|\ln d|$ for $b = 2$, and as fast as $d^{b/2}$ for $0 < b < 2$. Moreover, the sharp

boundary requirement for $b \geq 2$ is also sufficient for the distribution to remain a probability density. (Received January 22, 2011)

1069-35-178 **Igor Bock*** (igor.bock@stuba.sk), Dept. of Mathematics FEI, Slovak University of Technology, Ilkovicova 3, 81219 Bratislava, Slovak Rep, and **Jiri Jarusek** (jarusek@math.cas.cz), Mathematical Institute, Academy of Sciences of the Czech Republic, Zitna 25, 11567 Prague, Czech Rep. *Dynamic contact problems for von Kármán and Reissner-Mindlin plates.*

We explain the methods of solving the systems for the nonlinear von Kármán and linear Reissner-Mindlin plates in contact with a rigid obstacle. Resulting variational inequalities are solved by the penalization method. We start with an elastic von Kármán plate with unknown functions u, v, where u is a deflection of a middle surface $\Omega \subset \mathbb{R}^2$ and v is the Airy stress function. The plane $x_3 = 0$ serves as a rigid obstacle. The problem is transformed into a hyperbolic variational inequality for u with a nonlinear elliptic part. The existence of a solution is enabled by an L_1 estimate of the penalty term and by a proper use of the interpolation. Further we solve the case of viscoelastic full von Kármán system with unknowns perpendicular deflection with a rigid obstacle and a vector of plane displacements with Signorini conditions on the boundary. The viscosity has the character of a short memory. A viscoelastic bridge in a contact with a fixed road serves as a model. The third case to be investigated is the system of equations for a deflection and the angles of rotations representing the dynamic behaviour of a Reissner-Mindlin plate. We consider here the plate made of the viscoelastic material with a singular integral memory. (Received January 22, 2011)

1069-35-184 **Stanislaw Migorski*** (migorski@ii.uj.edu.pl), Jagiellonian University, Faculty of Mathematics and Computer Science, ul. Lojasiewicza 6, 30-348 Krakow, Poland. *History-dependent Subdifferential Inclusions and Hemivariational Inequalities in Contact Mechanics.*

We investigate a class of subdifferential inclusions involving a history-dependent term for which we provide an existence and uniqueness result. The proof is based on arguments on pseudomonotone operators and fixed point. Then we specialize this result in the study of a class of history-dependent hemivariational inequalities. These are variational formulations for nonconvex nondifferentiable functionals which arise in a large number of mathematical models describing quasistatic processes of contact between a deformable body and an obstacle. Next, we provide an example of a viscoelastic problem in which the frictional contact is modeled with subdifferential boundary conditions. We prove that this problem leads to a history-dependent hemivariational inequality in which the unknown is the velocity field. We apply our abstract result in order to prove the unique weak solvability of the corresponding contact problem. (Received January 23, 2011)

1069-35-196 **Yachun Li*** (ycli@sjtu.edu.cn), 800 Dongchuan Road, Department of Mathematics, Shanghai, 200240, Peoples Rep of China. *Some Qualitative Behavior of Solutions to Degenerate Parabolic-Hyperbolic Equations.*

In this talk, We would like to review some studies on degenerate parabolic-hyperbolic equations, and show some newly obtained well-posedness results of our own. (Received January 23, 2011)

1069-35-197 **Sun-Sig Byun*** (byun@snu.ac.kr), Department of Mathematics, Seoul National University, Seoul, 151-747, South Korea, and **Lihe Wang** (lwang@math.uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52242. *L^p estimates for higher order elliptic equations on Reifenberg flat domains.*

We will present recent result on higher order systems with coefficients that could large jumps in one direction. (Received January 23, 2011)

1069-35-198 **Chunqin Zhou*** (cqzhou@sjtu.edu.cn), 800 Dongchuan Road, Department of Mathematics, Shanghai, 200240, Peoples Rep of China. *Super-Liouville Equations on Closed Riemann Surfaces.*

Motivated by the supersymmetric extension of Liouville theory in the recent physics literature, we couple the standard Liouville functional with a spinor field term. The resulting functional is conformally invariant. We study geometric and analytic aspects of the resulting Euler-Lagrange equations, culminating in a blow up analysis. (Received January 23, 2011)

1069-35-209 **Dong Li** (dli@math.uiowa.edu), Department of Mathematics, 15 McLean Hall, The University of Iowa, Iowa City, IA 52242-1419, and **Kun Zhao*** (kzhao@mbi.osu.edu), 1735 Neil Ave, 381 Jennings Hall, The Ohio State University, Columbus, OH 43210. *Quantitative behavior of a parabolic-hyperbolic chemotaxis model.*

In this talk, recent progress on the quantitative behavior of classical solutions for a hyperbolic-parabolic system describing repulsive chemotaxis will be reported. It is shown that classical solutions to the Cauchy problem of the model exist globally in time for large initial perturbations around constant equilibrium states and the solutions tend to the constant states as time goes to infinity which predicts the phenomenon of collapse in chemotaxis. Moreover, explicit decay rates of the perturbations are identified when the initial perturbations are small. In particular, a striking result concerning the frequency-dependent decay rate is established based on a novel Fourier method. (Received January 23, 2011)

1069-35-215 **Masaharu Taniguchi*** (masaharu.taniguchi@is.titech.ac.jp), 2-12-1-W8-38 Ookayama, Meguro-ku, Tokyo, Tokyo 152-8552, Japan. *Multi-dimensional traveling fronts in bistable reaction-diffusion equations.*

This paper studies traveling front solutions of convex polyhedral shapes in bistable reaction-diffusion equations including the Allen-Cahn equations or the Nagumo equations. By taking the limits of such solutions as the lateral faces go to infinity, we construct a three-dimensional traveling front solution for any given $g \in C^\infty(S^1)$ with $\min_{0\le\theta\le 2\pi} g(\theta) = 0$. (Received January 24, 2011)

1069-35-223 **Hailiang Liu*** (hliu@iastate.edu), Ames, IA 50010. *ON A CLASS OF NONLOCAL DISPERSIVE EQUATIONS.*

This talk is concerned with a class of nonlocal dispersive equations –identified from dispersive schemes of the Hopf equation. This class includes integrable equations such as the Camassa-Holm equation and the Degasperis-Procesi equation, as special models. We investigate both global regularity of solutions and wave breaking phenomena. Analysis is based on either the use of some global invariants or exploration of favorable sign conditions of quantities involving solution derivatives. Some open problems will be discussed. (Received January 24, 2011)

1069-35-226 **George Avalos*** (gavalos@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588. *A Divergence-Free Finite Element Method for a Fluid-Structure PDE Interaction.*

In this talk we shall discuss a nonstandard usage of the classical Theorem of Brezzi, which has been used in the past to justify mixed finite element methods (FEM's) for uncoupled fluid flow models. Here we shall focus on a mixed FEM for approximating solutions to a partial differential equation (PDE) system which comprises (parabolic) Stokes fluid flow and a (hyperbolic) elastic structural equation. The appearance of such coupled PDE models in the literature is well-established, inasmuch as they mathematically govern many physical phenomena; e.g., the immersion of an elastic structure within a fluid. The coupling between the distinct hyperbolic and parabolic dynamics occurs at the boundary interface between the media. (Received January 24, 2011)

1069-35-234 **Nicolay Tanushev*** (nicktan@math.utexas.edu), Department of Mathematics, The University of Texas at Austin, 1 University Station, C1200, Austin, TX 75712. *Approximating High Frequency Waves with Gaussian Beams.*

Gaussian beams and their superpositions are approximate high frequency solutions to linear hyperbolic partial differential equations. From a simulation point of view, Gaussian beams are an attractive alternative to direct discretization methods (e.g. finite differences) as Gaussian beams do not have a fixed point-per-wavelength requirement and the method produces no numerical dispersion. To use Gaussian beam methods, one must represent the given initial and boundary data using suitable Gaussian beam parameters. In this talk, I will briefly review Gaussian beams and their superpositions and address the question of how to decompose high frequency initial and boundary data into a superposition of Gaussian beams. (Received January 24, 2011)

1069-35-240 **Tong Li*** (tong-li@uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52242, and **Zhi-An Wang**. *Nonlinear Stability of Large-amplitude Traveling Waves Arising from Chemotaxis.*

Traveling wave(band) behavior driven by chemotaxis was observed experimentally by Adler and was modeled by Keller and Segel. We establish the existence and the nonlinear stability of large-amplitude traveling wave solutions to a system of nonlinear conservation laws which is derived from the well-known Keller-Segel model describing cell(bacteria) movement toward the concentration gradient of the chemical that is consumed by the cells. (Received January 24, 2011)

1069-35-249 **Anthony W Leung**, Department of Math. Sci., University of Cincinnati, Cincinnati, OH 52246, **Xiaojie Hou*** (houx@uncw.edu), Department of Math. & Stat., UNCW, Wilmington, NC 28409, and **Wei Feng** (fengw@uncw.edu), Department of Math. & Stat., UNCW, Wilmington, NC 28409. *TRAVELING WAVE SOLUTIONS FOR LOTKA-VOLTERRA SYSTEM RE-VISITED.*

Abstract. Using a new method of monotone iteration of a pair of smooth lower- and upper-solutions, the traveling wave solutions of the classical Lotka-Volterra system are shown to exist for a family of wave speeds. Such constructed upper and lower solution pair enables us to derive the explicit value of the minimal (critical) wave speed as well as the asymptotic rates of the wave solutions at infinities. Furthermore, the traveling wave corresponding to each wave speed is unique modulo a translation of the origin. The stability of the traveling wave solutions with non-critical wave speed is also studied by spectral analysis of the linearized operator in exponentially weighted Banach spaces. (Received January 24, 2011)

1069-35-269 **John K Hunter*** (jkhunter@ucdavis.edu), Department of Mathematics, University of California at Davis, Davis, CA 95616, and **Mihaela Ifrim**, Department of Mathematics, University of California at Davis, Davis, CA 95616. *Large amplitude inertial oscillations in rotating shallow fluids.*

We derive a two-dimensional quasilinear Schrodinger equation that describes large amplitude inertial oscillations in a rotating shallow fluid which are coupled by weak pressure gradients. (Received January 24, 2011)

1069-35-270 **Chengbo Wang*** (wangcbo@jhu.edu), Department of Mathematics, Johns Hopkins University, 3400 N. Charles Street, Baltimore, MD 21218. *Long time existence for semilinear wave equations with low regularity.* Preliminary report.

In this talk, we will discuss two of our recent works on the long time existence for semi-linear wave equations for initial data with low regularity. The equations we will consider are as follows ($n \geq 2$, $p > 1$)

$$\begin{cases} \partial_t^2 u - \Delta u = a|\partial_t u|^p + b|\nabla_x u|^p \\ u(0,x) = u_0(x),\ \partial_t u(0,x) = u_1(x),\ x \in \mathbb{R}^n \end{cases}$$

For such problems with small data, there is a critical p (denoted by p_c) for the problem to have global existence. It was conjectured to be $p_c = 1 + \frac{2}{n-1}$ by R. Glassey (1983).

In the work with K. Hidano and K. Yokoyama, we are expected to verify this conjecture in the radial case, by proving the global existence for $p > p_c$, almost global existence for $p = p_c$, and long time existence for $1 < p < p_c$. Moreover, our lower bound on the lifespan will be essentially optimal.

In another work with D. Fang, we considered the cases $p \geq 3$ and $p \in \mathbb{N}$. For such indices, we were able to prove the similar results for the general data, by requiring some additional angular regularity. (Received January 24, 2011)

1069-35-278 **Changfeng Gui** (changfeng.gui@uconn.edu), Department of Mathematics, University of Connecticut, Storrs, CT 06269, and **Fang Zhang*** (fang.zhang@uconn.edu), Department of Mathematics, University of Connecticut, Storrs, CT 06269. *Symmetry of Entire Solutions to the Allen-Cahn Equation.*

In this paper, we shall prove the even symmetry of monotone entire solutions to the balanced Allen-Cahn equation with one spatial variable. Related results for the unbalanced Allen-Cahn equation are also discussed. (Received January 24, 2011)

1069-35-291 **Yulia Karpeshina*** (karpeshi@uab.edu), Department of Mathematics, UAB, 1300 University blvd, Birmingham, AL 35294-1170, **Young-Ran Lee** (younglee@sogang.ac.kr), Seoul, South Korea, and **Gunter Stolz** (stolz@uab.edu), Department of Mathematics, UAB, Birmingham, AL 35294-1170. *Quantum Trasport properties of Limit-Peridic Schroedinger Operator in dimension two.* Preliminary report.

We prove that in the high energy region there is an extensive set of generalized eigenfunctions which admit a good approximation by plane waves. These family of eigenfunctions supports ballistic quantum transport. (Received January 25, 2011)

1069-35-304 **Huilian Jia Jia*** (jiahl@mail.cjtu.edu.cn), No 28, West Xianning Road, Xi'An, Shaanxi 710049, Peoples Rep of China, and **Lihe Wang** (lwang.iowa@gmail.com), Iowa City, IA 52242. *Divergence Form Parabolic Equations On Noncylindrical Quasiconvex Domains.*

In this talk, we investigate the L^p regularity of divergence form parabolic equations on noncylindrical quasiconvex domains. Approximation by convex domain in the parabolic space is the main motivation for the noncylindrical

quasiconvex domain. Similar to the elliptic case, the maximal function technique, Vitali covering lemma and compactness method are the main analytical tools. (Received January 25, 2011)

1069-35-312 **Lihe Wang** and **Fengping Yao*** (fengpingyao@gmail.com), Department of Mathematics, Shanghai University, Shanghai, Shanghai 200436, Peoples Rep of China, and **Shulin Zhou**. *Second-order parabolic nondivergence equations with small BMO coefficients in R^n.*

In this paper we obtain the global regularity estimates in Orlicz spaces for second-order parabolic equations of nondivergence form with small BMO coefficients in the whole space. As a corollary we obtain L^p-type regularity for such equations. Our results improve the known results for such problems. (Received January 25, 2011)

1069-35-319 **Xiaofeng Ren*** (ren@gwu.edu), 2115 G Street, NW, Monroe Hall, Room 240, Washington, DC 20052. *Ansatz solutions to a problem of mean curvature and Newtonian potential.*

Pattern formation problems arise in many physical and biological systems as orderly outcomes of self-organization principles. Examples include animal coats, skin pigmentation, and morphological phases in block copolymers. Recent advances in singular perturbation theory and asymptotic analysis have made it possible to study these problems rigorously. In this talk I will discuss a central theme in the construction of various patterns as solutions to some well known PDE and geometric problems: how a single piece of structure built on the entire space can be used as an ansatz to produce a near periodic pattern on a bounded domain. We start with the simple disc and show how the spot pattern in morphogenesis and the cylindrical phase in diblock copolymers can be mathematically explained. More complex are the ring structure and the oval structure which can also be used to construct solutions on bounded domains. Finally we discuss the newly discovered smoke-ring structure and the toroidal tube structure in space. (Received January 25, 2011)

1069-35-330 **Gerhard Ströhmer*** (strohmer@iowa.uiowa.edu), Department of Mathematics, 15 MacLean Hall, Iowa City, IA 52242. *About Rotating Configurations of Compressible Fluids under the Influence of their own Gravity.*

We discuss conditions for the existence and stability of a number of configurations of compressible fluids rotating like a rigid body. The fluid is assumed to be surrounded by a free surface without surface tension, which prevents some perturbations from decaying exponentially. This causes some difficulties in showing dynamic nonlinear stability even for configurations that are stable in the sense of being local minima of the energy. (Received January 25, 2011)

1069-35-340 **Tae Gab Ha*** (tgha78@gmail.com), Ames, IA 50011. *General stabilization for the wave equation with boundary damping and source terms.*

In this talk, we are concerned with existence solutions and energy decay rates of the wave equation with

$$\begin{cases} u'' - \Delta u + p(u) = 0 \quad \text{in} \quad \Omega \times (0, +\infty), \\ u = 0 \quad \text{on} \quad \Gamma_0 \times (0, +\infty), \\ \frac{\partial u}{\partial \nu} + q_1(u') = |u|^\beta u \quad \text{on} \quad \Gamma_1 \times (0, +\infty), \\ u(x, 0) = u^0(x), \quad u'(x, 0) = u^1(x), \quad x \in \Omega, \end{cases}$$

where Ω is a bounded domain of $\mathbb{R}^n (n \geq 1)$ with boundary $\Gamma = \Gamma_0 \cup \Gamma_1$ of class C^2. Here , $\Gamma_0 \neq \emptyset$, Γ_0 and Γ_1 are closed and disjoint. Let ν be the outward normal to Γ. Δ stands for the Laplacian with respect to the spatial variables and $'$ denotes the derivative with respect to time t.

This work is devoted to prove the existence of global solutions using a potential well method and uniform decay rates of solutions of the wave equation without imposing any restrictive growth assumption on the damping term near zero. (Received January 25, 2011)

1069-35-359 **Yong YU*** (yong-yu@uiowa.edu), Iowa city, IA 52242. *Gamma Convergence of MCSH theory.* Preliminary report.

The talk will concern about the Gamma convergence of MCSH theory with external electromagnetic field. The critical electromagnetic fields will be discussed. (Received January 26, 2011)

1069-35-363 **Thierry Goudon**, **C. David Levermore** and **Weiran Sun*** (wrsun@uchicago.edu), Department of Mathematics, University of Chicago, Chicago, IL 60637. *Boundary Conditions of Linear Moment Systems.*

We present in this talk derivations of boundary conditions of linear moment systems that are compatible with given kinetic boundary conditions for linear kinetic equations. This is joint work with C. David Levermore and Thierry Goudon. (Received January 26, 2011)

1069-35-364 **Hongbin Chen*** (hbchen@mail.xjtu.edu.cn), Department of Mathematics, Xi'an Jiaotong University, Xi'an 029-710049 P.R. China, and **Yi Li** (yi-li@math.uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, Iowa 52242, USA. *ON HOT SPOTS CONJECTURE FOR NONCONVEX PLANAR DOMAIN.*

In this paper, we show that that the second Neumann eigenfunction attains its maximum and minimum values on its boundary.

More precisely, we prove

Theorem Let Ω be a bounded domain in the plane with two axes symmetry such that the tangent of the upper boundary curve and x_1 axis forms an acute angle . Let u be the Neumann eigenfunction with lowest eigenvalue among the functions that are odd with respect to x_1 ,i.e $u(-x_1, x_2) = u(x_1, x_2)$, and $u(x_1, x_2) > 0$ for $x_1 > 0$. Then

$$\frac{\partial u}{\partial x_1} > 0 \quad in\ \Omega.$$

(Received January 26, 2011)

1069-35-365 **Jürgen Batt** (batt@mathematik.uni-muenchen.de) and **Yi Li*** (yi-li@uiowa.edu). *Steady States of the Vlasov-Poisson System.*

We will present our study of the **positive** solutions $\phi = \phi(r)$ of

$$\phi'' + \frac{2}{r}\phi' = -\frac{r^{\lambda-2}}{(1+r^2)^{\lambda/2}}\phi^p, \qquad p > 1,\ \lambda > 0,$$

on $\mathbb{R}^+$. In particular, the structure of singular solutions. For $\lambda = 2$, these solutions are the radial solutions of

$$\Delta\phi = -\frac{1}{1+|x|^2}\phi^p,$$

on $\mathbb{R}^3$, which T. Matukuma proposed in 1935 for the description of certain stellar globular clusters in a steady state. They correspond to time-independent solutions of the Vlasov-Poisson system

$$\text{(V)} \qquad \partial_t f + v\partial_x f - \partial_x U(t,x)\,\partial_v f = 0$$

$$\text{(P)} \qquad \Delta U(t,x) = 4\pi\rho(t,x)$$

$$\text{(D)} \qquad \rho(t,x) := \int f(t,x,v)\,dv, \qquad x, v \in \mathbb{R}^3,$$

in the case of spherical symmetry; here $f = f(t,x,v) \geq 0$ is the distribution function of the considered system of gravitating mass in the space-velocity space and time $t \geq 0$, $U = U(t,x)$ the Newtonian potential and $\rho = \rho(t,x)$ the local density. (Received January 26, 2011)

37 ► Dynamical systems and ergodic theory

1069-37-2 **David Damanik*** (damanik@rice.edu), Rice University, Department of Mathematics, MS-136, Houston, TX 77251. *The Hofstadter butterfly, uniform hyperbolicity, and gap labeling.*

We describe how the Hofstadter butterfly, a fractal in the plane, arises numerically through the study of the eigenvalues of a parametrized family of finite matrices and discuss known results and open problems. In particular, we explain a recent approach, developed jointly with Artur Avila and Jairo Bochi, towards a description of the wings of this butterfly and those of a colored version due to Yosi Avron and Daniel Osadchy. This approach is based on a characterization of the wings of the butterfly in terms of uniform hyperbolicity of the associated SL(2,R)-cocycles. Our main results show that under suitable assumptions, uniform hyperbolicity is dense in the continuous category and all gaps allowed by the gap labeling theorem are generically open. (Received January 21, 2011)

1069-37-9 **Andrew Clark*** (andrew.clark@thomsonreuters.com), 8034 Dry Creek Circle, Niwot, CO 80503. *Application of Wavelets and Dynamical Systems Theory to Security Volatility.*

Multiresolution Analysis (MRA) via wavelets is used to understand stock and commodity market volatility at various time horizons. An analysis of the different horizons via the use of wavelet coefficients shows that short-dated intervals – anywhere from 1 day to approximately 4 weeks – is very noisy but has a significant level of determinism. This is known via an accurate computation of the largest Lyapunov exponent and confirmed by surrogate data tests.

Longer time horizons are characterized by a lower level of noise and larger wavelet coefficients – typically 1 order of magnitude or greater vs the short dated coefficients.

These larger coefficients indicate the strong influence of longer dated traders on the market in most market conditions. The stronger influence is measured by computing the energy of the original volatility series and then calculating the energy of each of the wavelets. The longer dated wavelets also show signs of determinism.

Forecasts are made for all the wavelets and good volatility forecasts going out 5–15 days business days is demonstrated. The same techniques are shown to generate good forecasts of volatility curves. (Received November 01, 2010)

1069-37-232 **Michael Goldstein*** (gold@math.toronto.edu), Dep of Mathematics University of Toronto, Bahen Centre 40 St. George St., Toronto, Ontario M5S 2E4, Canada. *Method of diagram re-summation for quasi-periodic Scrödinger equation.* Preliminary report.

Spectral analysis of quasi-periodic Schrödinger operators was extensively developed in last 20 years. However the existing methods do not allow one to solve the inverse problem for such operators, i.e to describe the set of all iso-spectral quasi-periodic potential with the same vector of frequencies. That is the main reason for which the Korteweg-de Vries equation $\partial_t\phi+\partial^3_{xxx}\phi+6\phi\partial_x\phi=0$ with quasi-periodic initial data, like $\phi|_{t=0}=\cos x+\cos(\omega x)$ is still an open problem. Some times ago together with D.Damanik we started a project in which we suggest a new approach to the analysis of the spectrum of the Scrödinger equation $-\psi''+\lambda V(x)\psi=E\psi$ with quasi-periodic potential V based on the re-summation of the diagram terms in the regime of small λ. In this talk I will give a preliminary report on the progress we made in this project. (Received January 24, 2011)

39 ► Difference and functional equations

1069-39-20 **Amera Habbeb Almusharrf**, 330 cedar ridge RD, Bowling green, KY 42101, and **Amera Habbeb Almusharrf*** (amera.almusharrf286@wku.edu), 330 cedar ridge rd, Bowling green, KY 42101. *Fractional Trigonometry.*

Abstract: my talk will be about fractional calculus and the development of fractional trigonometry based on the multi-valued fractional generalization of the exponential function, Mittag-Leffler function. Mittag-Leffler function plays important role in the solution of fractional order differential equations. The development of fractional calculus has involved new functions that generalize the exponential function. These functions allow the opportunity to generalize the trigonometric functions to "fractional" or "generalized" versions. In the talk, first I will give introduction and the history of the fractional calculus, Gamma function, definition of the fractional integral and derivative, Laplace transform. Finally, develops the relationships between Mittag-Leffler function and the new fractional trigonometric functions. Laplace transform are derived for the new functions and are used to generate the solution sets for various classes of fractional differential equations. (Received November 22, 2010)

1069-39-265 **Maxim Zinchenko***, Department of Mathematics, University of Central Florida, Orlando, FL 32816. *Khrushchev's Theory for OPUC via Right Limits.*

In this talk I will discuss Khrushchev's theory on weak limits of measures and ratio asymptotic of orthogonal polynomials on the unit circle via studying the right limits of CMV matrices. This approach provides simpler and more streamlined proofs of previously known results and in some cases allows for further refinements.

This is joint work with J. Breuer and E. Ryckman. (Received January 24, 2011)

42 ► Fourier analysis

1069-42-131 **Alexei Poltoratski*** (alexeip@math.tamu.edu). *Spectral gaps for sets and measures.*

Problems on spectral gaps, i.e. gaps in the support of the Fourier transform, for finite complex measures on the real line have been studied by analysts throughout the 20th century. One of the reasons for such prolonged

interest is the large number of relations between such problems and other areas of analysis and differential equations. In my talk I will discuss recent solutions to two of such classical problems, the Gap Problem and the Type problem, as well as relations to spectral problems for differential operators. (Received January 20, 2011)

43 ► Abstract harmonic analysis

1069-43-237 **Chunping Xie*** (xie@msoe.edu), Departmentof Mathematics, Milwaukee School of Engineering, 1025 N. Broadway, Milwaukee, WI 53202. *A_p Functions and Some Operators.* Preliminary report.

This paper has studied the relationship between A_p functions and the boundedness of Hardy-Littlewood maximal operator and Calderon-Zygmund operator on $L^{p,\lambda}(w)$. Also it has dealt with the extrapolation theorem of $L^{p,\lambda}(w)$. (Received January 24, 2011)

46 ► Functional analysis

1069-46-205 **Mihai Stoiciu*** (mstoiciu@williams.edu), Department of Mathematics and Statistics, Bronfman Science Center, Williams College, Williamstown, MA 01267. *Transition in the Eigenvalue Distribution for Self-Adjoint and Unitary Operators.* Preliminary report.

We describe a few classes of self-adjoint and unitary operators which exhibit a transition in the distribution of their eigenvalues. More precisely, we consider operators with various spectral measures and investigate the change in their microscopic eigenvalue distribution. As the spectral measures approach an absolutely continuous measure, the repulsion between the eigenvalues increases and the eigenvalue distribution converges to the "clock" (or "picket fence") distribution. (Received January 23, 2011)

1069-46-361 **Gheorghe Nenciu** and **Irina Nenciu*** (nenciu@uic.edu). *On essential self-adjointness for magnetic Schroedinger and Pauli operators.*

We present results concerning the magnetic confinement of quantum particles on the unit disk $\mathbb{D}$ in $\mathbb{R}^2$, i.e. we wish to achieve confinement solely by means of the growth of the magnetic field $B(x)$ near the boundary of the disk. In the spinless case we show that $B_{rad}(|x|) \geq \frac{\sqrt{3}}{2} \cdot \frac{1}{(1-r)^2} - \frac{1}{\sqrt{3}} \frac{1}{(1-r)^2 \ln \frac{1}{1-r}}$, for $|x| = r$ close to 1, insures the confinement provided we assume that the non-radially symmetric part of the magnetic field is not very singular near the boundary. Both constants $\frac{\sqrt{3}}{2}$ and $-\frac{1}{\sqrt{3}}$ are optimal. This answers, in this context, an open question of Y. Colin de Verdière and F. Truc. We also derive growth conditions for radially symmetric magnetic fields which lead to confinement of spin $\frac{1}{2}$ particles. This is joint work with G. Nenciu. (Received January 26, 2011)

47 ► Operator theory

1069-47-123 **Helge Krueger*** (helge@caltech.edu), Caltech Department of Mathematics, MC 253-37, 1200 E California Blvd, Pasadena, CA 91125. *The spectrum of the skew-shift Schroedinger operator contains an interval.*

I will discuss my result that the spectrum of the skew-shift Schroedinger operator, i.e. a discrete Schroedinger operator with potential V(n) = f(alpha n^2) with f one-periodic, contains an interval at large coupling. In particular, how the proof relies on certain multi-scale methods. (Received January 19, 2011)

1069-47-183 **Anna Skripka*** (skripka@math.ucf.edu). *Spectral shift function of order $n \geq 3$.*

The talk will discuss analogs of Krein's (1953) and Koplienko's (1984) spectral shift functions for perturbations in the Schatten-von Neumann class of order $n \geq 3$. Existence of these functions was recently established in joint work with D. Potapov and F. Sukochev. (Received January 23, 2011)

1069-47-268 **Konstantin A. Makarov***, Department of Mathematics, 202 Mathematical Sciences Bldg, University of Missouri, Columbia, MO 65211, and **Albrecht Seelmann**. *On a Subspace Perturbation Problem.* Preliminary report.

One of the main problems of perturbation theory for linear operators is to understand how the spectrum and invariant subspaces of an operator change when the operator depends on a parameter. We show how to obtain sharp estimates on the magnitude of the rotation angle between spectral subspaces in a perturbation problem for bounded self-adjoint operators. As an application, we obtain a new estimate on the norm of the difference

of two spectral projections associated with isolated parts of the spectrum of the perturbed and unperturbed operators, respectively. (Received January 24, 2011)

1069-47-293 **Alexander Gordon*** (aygordon@uncc.edu), aygordon@uncc.edu, and **Jason Holt**, **Ari Laptev** and **Stanislav Molchanov**. *On the Simon-Spencer Theorem.*

In the talk, a simple proof will be outlined of the following version of the fundamental result of Simon and Spencer: Let $H = -d^2/dx^2 + V(x)$ be a 1-D Schrödinger operator on the half-axis with boundary condition $y(0)\cos\alpha - y'(0)\sin\alpha = 0$. Suppose that $\sup_{x\geq 0}\int_x^{x+1} v_-(t)dt < \infty$ and $\sup_{x\geq 0}\int_x^{x+1} v(t)dt = \infty$. Then H has no absolutely continuous spectrum. (Received January 25, 2011)

49 ► Calculus of variations and optimal control; optimization

1069-49-281 **Arun Chockalingam*** (arunachalam@purdue.edu), 315 N. Grant St, Lafayette, IN 47907, and **Shaunak Dabadhghao**. *Pricing American Options without Smooth Pasting.*

The American option pricing problem gives rise to a free-boundary problem in partial differential equations. Chockalingam and Muthuraman (2010) propose a novel numerical scheme to solve this problem. The scheme can handle a variety of stochastic models and takes advantage of the smooth pasting condition to derive the optimal exercise boundary. The smooth pasting condition,however, does not hold in certain cases. In this talk, we derive another update condition using error bounds for options priced using suboptimal exercise policies. This update condition does not depend on the smooth pasting condition. We demonstrate the use of this new condition with the numerical scheme to price options under a variety of stochastic models. (Received January 24, 2011)

1069-49-354 **Akhtar A. Khan*** (aaksma@rit.edu), School of Mathematical Sciences, Rochester Institute of Technology, 85 Lomb Memorial Drive, Rochester, NY 14623. *Stability of Elliptic Inverse Problems via a Modified Output Least Squares.*

This talk will focus on the inverse problem of identifying certain variable parameters in elliptic partial differential equations. The main emphases will be on the use of the modified output least-squares functional for studying stability issues in solving the elliptic inverse problem. Regularization will be used to handle the data perturbation as well as the lack of some coercivity for the direct problem. The case of smooth as well as nonsmooth coefficients will be considered. Finite element based numerical examples will be presented. Several applications of the results will be discussed. (Received January 25, 2011)

52 ► Convex and discrete geometry

1069-52-204 **Austin W. Shapiro*** (auspex@umich.edu). *Bounds on the number of integer points in a polytope via concentration estimates.*

It is generally hard to count, or even estimate, how many integer points lie in a polytope P. Barvinok and Hartigan have approached the problem by way of information theory, showing how to efficiently compute a random vector X which samples the integer points of P with (computable) constant mass, but which may also land outside P. Thus, to count the integer points of P, it suffices to determine the frequency with which X falls in P.

I will present efficiently computable upper bounds on this frequency, expressed by way of the point concentration of a sum of independent random variables. As a consequence of these bounds, if P is suitably presented by n linear inequalities and m linear equations (m fixed), then under mild conditions separating $\mathbf{E}[X]$ from the origin, the frequency with which X falls in P is $O(n^{-m/2})$ as $n \to \infty$. I will discuss the relation of this work to the literature on "Littlewood-Offord problems." (Received January 23, 2011)

53 ► Differential geometry

1069-53-329 **Jason Cantarella*** (jason.cantarella@gmail.com), UGA Math Department, Boyd GSRC, Athens, 30602. *Sub-Riemannian and Symplectic Geometry of Polygon Spaces.* Preliminary report.

This is a mostly expository talk about the symplectic structure on the space of polygons in Euclidean space. A lot of work has been done on the torus actions on this space generated by commuting "bending flows" formed by rotating a portion of the polygon rigidly around the line joining two vertices. Here we discuss the geometry of the (singular) plane distributions generated by taking collections of non-commuting bending flows, which seems to be considerably less well explored. We will give some (very) preliminary results, and an outline of some applications to geometric knot theory. The results are joint work with the UGA Geometry VIGRE group. (Received January 25, 2011)

55 ► Algebraic topology

1069-55-23 **Vesna Stojanoska*** (vesna@math.northwestern.edu), Department of Mathematics, Northwestern University, 2033 Sheridan Rd., Evanston, IL 60208. *Serre duality and topological modular forms.* Preliminary report.

It has been observed that certain localizations of the spectrum of topological modular forms tmf are self-dual (Mahowald-Rezk, Gross-Hopkins). We provide an integral explanation of these results that is internal to the geometry of the (compactified) moduli stack of elliptic curves $\mathcal{M}$, yet is only true in the derived setting. When 2 is inverted, choice of level-2-structure for an elliptic curve provides a geometrically well-behaved cover of $\mathcal{M}$, which allows one to consider tmf as the homotopy fixed points of $tmf(2)$, topological modular forms with level-2-structure, under a natural action by $GL_2(\mathbb{Z}/2)$. As a result of Grothendieck-Serre duality, we obtain that $tmf(2)$ is self dual. The vanishing of the associated Tate spectrum then makes tmf itself Anderson self-dual. (Received November 28, 2010)

1069-55-88 **Thomas Gunnarsson** and **Ross E Staffeldt*** (ross@nmsu.edu), Department of Mathematical Sciences, MSC 3MB P.O.Box 30001, New Mexico State University, Las Cruces, NM 88003. *Segal operations in the algebraic K-theory of topological spaces.* Preliminary report.

Waldhausen originally defined Segal operations for $A(*)$, the algebraic K-theory of the one-point topological space, extending a construction Segal used to define operations in stable homotopy. Segal used his operations to give a proof of the Kahn-Priddy theorem, splitting the stable homotopy groups of spheres in a geometrically significant manner, and Waldhausen used his operations to complete the proof of the splitting $A(X) \simeq \Omega^\infty S^\infty(X_+) \times Wh^{\mathrm{Diff}}(X)$. This talk will describe the construction of Segal operations

$$A(BG) \to \prod_{n\geq 1} A(BG \times B\Sigma_n),$$

where BG is the classifying space of a finite simplicial abelian group and $B\Sigma_n$ is the classifying space of the symmetric group on n letters. There will also be discussion of consequences of the existence of these operations. (Received January 14, 2011)

1069-55-107 **Angelica M Osorno*** (aosorno@math.uchicago.edu). *Spectra associated to symmetric monoidal bicategories.*

In this talk, we show how to construct a spectrum from a symmetric monoidal bicategory, using Segal's Γ-spaces. As an example, we use this machinery to construct a delooping of the K-theory of a bimonoidal category as defined by Baas, Dundas and Rognes. (Received January 18, 2011)

1069-55-203 **Michael A Mandell***, Department of Mathematics, Rawles Hall, 831 E 3rd St, Bloomington, IN 47405. *The Multiplication on BP.*

BP is an E_4 ring spectrum. The E_4 structure is unique up to homotopy. Joint work with Maria Basterra. (Received January 23, 2011)

1069-55-210 **Rosona Eldred*** (reldred2@math.uiuc.edu). *New constructions for Goodwillie Calculus.* Preliminary report.

We will survey some new results about the equivalence of different towers whose inverse limits agree with the inverse limit of the Calculus tower defined by T. Goowillie. We will begin by discussing some new results in unbased calculus (joint with K. Bauer, B. Johnson and R. McCarthy) and finish by indicating how we proved

a conjecture by Goodwillie that generalized this earlier work to more general settings. (Received January 23, 2011)

1069-55-224 **Tyler D. Lawson*** (tlawson@math.umn.edu), 206 Church Street S.E., Minneapolis, MN 55455. *Topological modular forms with level 3 structure.*

Ausoni and Rognes have initiated a program to study algebraic K-theory by the chromatic filtration, and part of this program involves studying the algebraic K-theory of truncated Brown-Peterson spectra. This talk will discuss joint work with Niko Naumann that, at the prime 2, links generalizations of these truncated objects with moduli spaces of elliptic curves. (Received January 24, 2011)

1069-55-328 **Michael Anthony Hill*** (mikehill@virginia.edu), VA. *Multiplications and Equivariance.* Preliminary report.

We discuss some of the points of interest in the intersection of commutative rings and equivariant stable homotopy theory based on recent developments in stable homotopy theory. (Received January 25, 2011)

1069-55-334 **Ricardo Andrade*** (randrade@math.stanford.edu). *Filtered spaces and localizations.*

To each filtered space X one can associate a topological category $\overrightarrow{path}(X)$ (sometimes called the exit-path category) whose morphisms are paths in X which respect the filtration. I will discuss how forgetting stages of the filtration in X leads to Dwyer-Kan localizations of $\overrightarrow{path}(X)$. Several applications of this result will be given, particularly to the study of topological chiral homology. (Received January 25, 2011)

57 ► Manifolds and cell complexes

1069-57-48 **Scott A Taylor*** (sataylor@colby.edu), 5832 Mayflower Hill, Waterville, ME 04901, and **Maggy Tomova**. *Thin position for graphs in 3-manifolds.*

Scharlemann and Thompson's thin position for graphs in the 3–sphere has been a very useful tool for understanding Heegaard splittings and tunnel number one knots in the 3–sphere, but has not been very useful for the study of knots and graphs in other 3–manifolds. I will describe joint work with Maggy Tomova that introduces a new type of thin position (based on earlier work of Hayashi and Shimokawa) for finite graphs in compact orientable 3–manifolds. We prove that if a graph is put into minimal bridge position with respect to a Heegaard surface then either a degenerate situation happens or the bridge surface can be untelescoped so that every thin surface is essential (incompressible and not boundary-parallel) and every thick surface is strongly irreducible. (Received December 21, 2010)

1069-57-56 **Jesse Johnson** (jjohnson@math.okstate.edu), Department of Mathematics, Oklahoma State University, Stillwater, OK 74078, **Yair N Minsky** (yair.minsky@yale.edu), 10 Hillhouse Ave, New Haven, CT 06520-8283, and **Yoav Moriah*** (ymoriah@tx.technion.ac.il), Department of Mathematics, Technion, 32000 , Israel. *Heegaard splittings with large subsurface distances.*

It is shown that sub-surfaces of a Heegaard surface for which the relative Hempel distance of the splitting is sufficiently high have to appear in any Heegaard surface of genus bounded by half that distance. (Received January 08, 2011)

1069-57-71 **Martin Scharlemann*** (mgscharl@math.ucsb.edu), Mathematics Department, UC Santa Barbara, Santa Barbara, CA 93106-3080. *Generating the genus g+1 Goeritz group of a genus g handlebody.* Preliminary report.

If Powell was correct when he found a natural set of generators for the Goeritz group of the 3-sphere, his work would also suggest a natural set of generators for the Goeritz group of a handlebody. One might hope to reverse such an argument, proving Powell's conjecture by inductively finding generators for the genus g Goeritz group of a genus g - i handlebody, i = 1, ..., g. The first step can be done using classical tools, but after that the classical approach gets murky. Is there a thin position argument instead, that would also work for the later steps? (Received January 13, 2011)

1069-57-148 **J Arsuaga** and **Y Diao*** (ydiao@uncc.edu), Department of Mathematics and Statistics, UNC Charlotte, 9201 University City Blvd, Charlotte, NC 28223, and **R Kaplan** and **M Vazquez**. *The effects of density on the topological structure of the mitochondrial DNA from trypanosomes.* Preliminary report.

Trypanosomatid parasites, trypanosoma and lishmania, are the cause of disease and death in many third world countries. One of the most unusual features of these organisms is the 3 dimensional organization of their

mitochondrial DNA into maxi and minicircles. In some of these species minicircles are confined into a small volume and are interlocked, forming a gigantic network. How this network was selected during evolution and how it is maintained, replicated and segregated is mostly unknown. Here we investigate the effects of minicircle density on the topology of the network using a simplified model where randomly oriented minicircles are placed on the plane with their centers on the vertices of the simple square lattice. We analytically show that a finite positive critical percolation density exists and that the probability of a network is completely saturated approaches one exponentially as the density increases when the minicircle field is bounded. We carried out numerical studies to estimate these quantities and also to estimate biologically relevant properties of the network (such as the average valence of the network). Our simulations show that the mean valence of the network near saturation density is close to 3 and the obtained network is rather heterogeneous. (Received January 21, 2011)

1069-57-219 **David Bachman**, **Ryan Derby-Talbot** and **Eric Sedgwick*** (esedgwick@cdm.depaul.edu). *Surfaces that become isotopic after Dehn filling.* Preliminary report.

We show that for "most" Dehn fillings on a torus boundary component of a 3-manifold, the set of closed essential surfaces (up to isotopy) remains unchanged. In order to prove the result, we introduce the *compressing sequence*, an analog to thin position designed to discretize an isotopy in the presence of a knot. (Received January 24, 2011)

1069-57-228 **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)

1069-57-233 **David C Bachman*** (bachman@pitzer.edu), Pitzer College, 1050 N. Mills Ave, Claremont, CA 91711. *Normalizing Topologically minimal surfaces.* Preliminary report.

Topologically minimal surfaces arise naturally in a wide variety of 3-manifold settings. We discuss a program to show that any such surface can be isotoped into some normal form with respect to a fixed triangulation. This result opens the door to a large number of problems in Dehn surgery. (Received January 24, 2011)

1069-57-256 **Alexander Coward*** (coward@math.ucdavis.edu), Mathematics Department, One Shields Avenue, University of California, Davis, CA 95616, and **Marc Lackenby** (lackenby@maths.ox.ac.uk). *An upper bound on Reidemeister moves.*

Given any two diagrams of the same knot or link, we provide an explicit upper bound on the number of Reidemeister moves required to pass between them in terms of the number of crossings in each diagram. This provides a new and conceptually simple solution to the equivalence problem for knot and links. (Received January 24, 2011)

1069-57-261 **Ryan C Blair***, ryblair@math.upenn.edu, and **Maggy Tomova**, maggy-tomova@uiowa.edu. *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_α and K'_α so that $w(K_\alpha \# K'_\alpha) = max\{w(K_\alpha), w(K'_\alpha)\}$. This is the first known example of a pair of knots such that $w(K\#K') < w(K) + w(K') - 2$. (Received January 24, 2011)

1069-57-271 **Mario Eudave-Munoz*** (mario@matem.unam.mx), Instituto de Matematicas, Universidad Nacional Autonoma de Mexico, Circuito Exterior, Ciudad Universitaria, 04510 Mexico, DF, Mexico, and **Fabiola Manjarrez-Gutierrez**. *Additivity of circular width.* Preliminary report.

F. Manjarrez-Gutierrez defined circular thin position and circular width for a knot in S^3. The idea is to find collections of surfaces $\{S_i\}_{i=1}^n$ and $\{F_i\}_{i=1}^n$, properly embedded in the knot exterior, where each surface consists of a Seifert surface for the knot and perhaps some closed components, so that by cutting open along the collection $\{F_i\}_{i=1}^n$, we get a collection of disjoint submanifolds whose Heegaard surfaces are the $S'_i s$. A complexity $c(S_i)$ is assigned to each surface, and the circular width of the knot, $cw(K)$, is defined as the minimal ordered n-tuple

encoding these complexities. A decomposition realizing the circular width of the knot is called circular thin position of the knot. In this report we study the behavior of the circular width with respect to connected sums, and prove that it is additive in some cases, namely $cw(K_1\#K_2) = cw(K_1)\#cw(K_2)$. (Received January 24, 2011)

1069-57-274 **Dorothy Buck***, Dept of Mathematis, Imperial College London, London, sw7 2az, England, and **Kenneth L. Baker**. *The Classification of Rational Subtangle Replacements, with Applications to Complex Nucleoprotein Assemblies.*

Many proteins cleave and reseal DNA molecules in precisely orchestrated ways. Modelling these reactions has often relied on the axis of the DNA double helix being circular, so these cut-and-seal mechanisms can be tracked by corresponding changes in the knot type of the DNA axis. However, when the DNA molecule is linear, or the protein action does not manifest itself as a change in knot type, or the knots types are not 4-plats, these knot theoretic models are less germane.

We thus give a taxonomy of local DNA axis configurations. More precisely, we characterise all rational tangles obtained from a given rational tangle via a rational subtangle replacement (RSR).

Biologically then, this classification is endowed with a distance that determines how many enzyme-mediated reactions of a particular type are needed to proceed from one local DNA conformation to another, or indeed if it is even possible.

We conclude by discussing a variety of biological applications of this categorisation, including type-II topoisomerase, site- specific recombinase, and transposase-mediated reactions. (Received January 24, 2011)

1069-57-275 **Kenneth L. Baker*** (kenken@math.miami.edu), Dept of Mathematics, University of Miami, 1365 Memorial Drive, Coral Gables, FL 33146, and **Dorothy Buck**. *Rational Subtangle Replacements between Rational Tangles.*

A rational subtangle replacement (RSR) is the excision of a rational (sub)tangle from a 3-manifold with a properly embedded 1-manifold followed by the insertion of another.

Here, we classify the pairs of rational tangles that may be related by an RSR, and exhibit sites where these may occur. When the RSR has distance at least 2, we show that these are the only sites for such transformations. This builds on work of Berge, Ernst and Gabai. (Received January 24, 2011)

1069-57-285 **Alexander Zupan*** (alexander-zupan@uiowa.edu), University of Iowa, Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52242. *Thin position of cable knots.*

We prove that thin position of any cable knot in S^3 is achieved by cabling a thin position of its companion in an "obvious" way. This proves a special case of a conjecture of the author relating the width of a satellite knot, the width of its companion, and the winding number of its pattern. The conjecture is analogous to a classical inequality proved by Schubert and later by Schultens regarding the bridge numbers of a satellite knot and its companion and the index of its pattern. Time permitting, we will discuss further progress towards resolving the conjecture. (Received January 24, 2011)

1069-57-296 **Kenneth L. Baker**, **Cameron McA. Gordon** and **John Luecke***, University of Texas, Math Department, 1 University Station C1200, Austin, TX 78712. *Bridge number and non-integral Dehn surgery.* Preliminary report.

We show there is a function w from the natural numbers to itself with the following property. Let K be a hyperbolic knot in the 3-sphere. Let $K(p/q)$ denote the p/q-Dehn surgery on K. Let K' be the core of the attached solid torus in this Dehn surgery, thought of as a knot in $K(p/q)$. Let F be a Heegaard surface for $K(p/q)$ of genus g. If $|q| > 1$ and p/q is not a g-boundary slope, then the bridge number of K' with respect to the Heegaard splitting of F is at most $w(g)$. (Received January 25, 2011)

1069-57-297 **Elizabeth Denne***, Department of Mathematics & Statistics, Smith College, Northampton, MA 01063, and **John M Sullivan** and **Nancy C Wrinkle**. *Flat-ribbon links in $\mathbb{R}^2$ and the medial axis.* Preliminary report.

Links are modeled as flat ribbons immersed in $\mathbb{R}^2$ without folding. Understanding the medial axis of flat ribbon links give insight to their structure. This talk will give an overview of the ideas involved, including Möbius structures and the set of maximal round balls. (Received January 25, 2011)

1069-57-302 **Claus Ernst*** (claus.ernst@wku.edu), Dept. of Math. and Comp. Sci., WKU, 1906 College Heights Blvd, Bowling Green, KY 42101, and **Attila Por** (attila.por@wku.edu), Dept. of Math. and Comp. Sci., WKU, 1906 College Heights Blvd, Bowling Green, KY 42101. *Average crossing number, total curvature and ropelength of thick knots.*

Let K be a smooth knot of unit thickness embedded in in the space R^3 with length $L(K)$ and total curvature $\kappa(K)$. Then $acn(K) \leq c \cdot L(K) \cdot \sqrt{\kappa(K)}$ where $acn(K)$ is the average crossing number of the embedded knot K and $c > 0$ is a constant independent of the knot K . This relationship has been conjectured in an article by G. Buck and J. Simon where it is shown that the square root power on the curvature is the lowest possible. In the last part, we give several examples to illustrate some relationships between the three quantities average crossing number, total curvature and ropelength. (Received January 25, 2011)

1069-57-311 **Fabiola Manjarrez-Gutiérrez*** (fabiola@matem.unam.mx), **Víctor Núñez** and **Enrique Ramírez-Losada**. *Circular thin position for free genus one knots.* Preliminary report.

A circular handle decomposition for the exterior of a knot $E(K)$ is a structure: $E(K) = F \times I \cup N_1 \cup T_1 ... \cup N_m \cup T_m$, where F is a Seifert surface for K, N_i is a collection of 1-handles and T_i is a collection of 2-handles. We can re-order the handles in such a way that the regular level surfaces are as simple as possible, giving rise to the definition of circular thin position of the knot exterior. A knot exterior in circular thin position has a sequence of Seifert surfaces which are alternately incompressible and weakly incompressible. In our context a fibered knot is a knot whose knot exterior has a circular thin position with one and only one incompressible surface and none weakly incompressible surface. An almost fibered knot is a knot whose exterior possesses a circular thin position in which there is one and only one weakly incompressible Seifert surface and one and only one incompressible Seifert surface. All non-fibered knots up to ten crossings are handle number one knots, in our context these knots are almost fibered. In this talk we show two families of free genus one knots which are almost fibered. The first family admits a single 1-handle and a single 2-handle in and the second one admits two 1-handles and two 2-handles. (Received January 25, 2011)

1069-57-315 **Marion Moore Campisi*** (campisi@math.utexas.edu). *α-sloped thin position for 3-manifolds.*

We introduce the concept of α-sloped thin position of 3-manifolds M with torus boundary and examine its relationship to generalized Heegaard splittings of the manifolds resulting from Dehn filling on M. We compare α-sloped thin position of 3-manifolds to other types of thin position for knots and 3-manifolds and discuss how this kind of decomposition gives an organic picture of M and allows the structure of the manifold to dictate the most natural slope on the boundary. Additionally, we provide illustrative examples and questions motivating the study of α-sloped thin position. (Received January 25, 2011)

1069-57-320 **Yo'av Rieck*** (yoav@uark.edu), Math department (301 SCEN), 1 University Dr, Univeristy of Arkansas, Fayetteville, AR 72701, and **Yasushi Yamashita**. *The Link Volume.*

W introduce the link volume, a 3-manifold invariant that measures how efficiently a 3-manifold can be represented as a branched cover of S^3. Some of the basic properties and open questions about the link volume will be stated. (Received January 25, 2011)

1069-57-336 **Matt Rathbun*** (mrathbun@math.msu.edu), Michigan State University, A320 Wells Hall, East Lansing, MI 48824-1027. *Tunnel One, Fibered Links.*

All fibered links can be constructed from the unknot by a sequence of operations called plumbing (and then de-plumbing) Hopf bands. Interestingly, if a fibered link has an unknotting tunnel that happens to lie in the fiber, then plumbing a Hopf band along the tunnel results in a new fibered link that is again tunnel number one. Natural questions are whether this restricted plumbing can always be performed, and whether this is sufficient to construct all tunnel one, fibered links. I will answer the first question affirmatively, and discuss progress towards answering the second. (Received January 25, 2011)

1069-57-352 **David Bachman** (bachman@pitzer.edu), **Ryan Derby-Talbot*** (rdt@questu.ca) and **Eric Sedgwick** (esedgwick@cdm.depaul.edu). *Heegaard surfaces in toroidal 3-manifolds.*

We prove a finiteness result for a class of surfaces that includes almost normal surfaces in 3-manifolds with multiple torus boundary components, generalizing a result of Jaco and Segwick. A consequence of this is that in 3-manifolds with "sufficiently complicated" JSJ decompositions, every Heegaard splitting is an amalgamation along the JSJ tori. (Received January 25, 2011)

1069-57-353 **Yuanan Diao**, **Claus Ernst**, **Kenneth Hinson** and **Uta Ziegler*** (uta.ziegler@wku.edu), Dept. of Mathematics and Computer Scienc, WKU, 1906 College Heights Blvd, Bowling Green, KY 42101. *Generating Polymers in Confinement.* Preliminary report.

A polymer in confinement is represented by an N-segment, unit-length, free-jointed, closed polygon in spherical confinement, $P = \{X_0, X_1, X_2, X_3, \ldots X_N = X_0\}$. We present a fast algorithm to generate such polygons. Let r_i be the distance from X_i to X_0, that is $r_i = |X_i|$. At each step k in the generation process, the k-th segment of the polygon is added ideally based on the conditional probability function $G(r_k|r_{k-1} \wedge m)$, that is the probability that X_k's distance to X_0 is r_k, given that X_{k-1}'s distance to X_0 is r_{k-1} and that the polygon must be closed in m steps. There exists no closed formula for G and thus approximations of G for various values of r_{k-1} and m must be used based on numeric data collected from millions of equilateral random walks. The runtime for the generation is $O(N)$, although significant time is needed (though only once) to obtain the approximations of G. (Received January 25, 2011)

58 ► Global analysis, analysis on manifolds

1069-58-235 **Klaus Kirsten*** (klaus_kirsten@baylor.edu), Department of Mathematics, Baylor University, Waco, TX 76798. *Zeta function on surfaces of revolution.* Preliminary report.

We consider the surface of revolution M generated by a positive, differentiable function f on $[0, L]$. Taking the metric induced by the standard Euclidean metric of R^3 we obtain a Riemannian manifold (M, g) with nonempty boundary. On (M, g) we consider the Laplacian and its associated zeta function. We analyze in detail how the zeta function determinant and the Casimir energy depend on the function f. (Received January 24, 2011)

60 ► Probability theory and stochastic processes

1069-60-16 **Agostino Capponi*** (capponi@purdue.edu) and **Jaksa Cvitanic** (cvitanic@hss.caltech.edu). *Contracting with Noisy Observations and Misreporting.*

We extend the classical contracting model in continuous time by assuming that the project value process controlled by the agent can only be observed with noise. Thus, both the agent and the principal hiring the agent have to filter the observations when deciding on the optimal contracting agreement. We find that, unlike in the classical case, the optimal contract is path dependent. We also allow for the possibility that the agent misreports the project value and we show that the optimal misreporting level is not zero even if the market is aware of misreporting, as long as the latter cannot be contracted upon. (Received November 13, 2010)

1069-60-58 **Lingfei Li*** (lilf@u.northwestern.edu), 2145 Sheridan Road C217, Evanston, IL 60208, and **Vadim Linetsky**, 2145 Sheridan Road C251, Evanston, IL 60208. *Subordinate Ornstein-Uhlenbeck Processes: Properties, Applications and Extensions.*

We study Subordinate OU (SubOU) processes which are obtained by time changing an OU diffusion with a Levy subordinator. We construct their sample path decomposition and show that they possess mean-reverting jumps and study their equivalent measure transformations and the spectral representation of the transition semigroup. As an application, we propose a new class of commodity models with mean-reverting jumps based on SubOU processes. We extend SubOU processes by further time change them with the integral of a CIR process plus a deterministic function of time to induce stochastic volatility and time inhomogeneity (such as seasonality). We obtain analytical solutions for commodity futures options in terms of Hermite expansions. The models are consistent with the initial futures curve, exhibit Samuelson's maturity effect, and are flexible enough to capture a wide variety of implied volatility smile patterns observed in energy, metals, and agricultural commodities futures options. (Received January 10, 2011)

1069-60-75 **BEN NIU*** (nb6697955@gmail.com), 575 W. MADISON STREET, APT 3004, CHICAGO, IL 60661, and **Fred Hickernell** (nben@iit.edu), Chicago, 60661. *Multi-level Monte Carlo Algorithms for High-dimensional Option Pricing.*

Pricing a path-dependent financial derivative, such as an Asian option, requires the computation of $\mathbb{E}(g(B))$, the expectation of a payoff function g, that depends on a Brownian motion B. Employing a standard series expansion of B the latter problem is equivalent to the computation of the expectation of a function of the corresponding i.i.d. sequence of random coefficients. This motivates the construction and the analysis of algorithms for numerical integration with respect to a product probability measure on the sequence space $\mathbb{R}^{\mathbb{N}}$. The class of

integrands studied in this paper is the unit ball in a reproducing kernel Hilbert space obtained by superposition of weighted tensor product spaces of functions of finitely many variables. Combining tractability results for high-dimensional integration with the multi-level technique we obtain new algorithms for infinite-dimensional integration. These deterministic multi-level algorithms use variable subspace sampling and they are superior to any deterministic algorithm based on fixed subspace sampling with respect to the respective worst case error. Numerical experiments will be implemented. (Received January 13, 2011)

1069-60-81 **Sunil Chhita*** (schhita@math.brown.edu), Box 1917, 151 Thayer Street, Providence, RI 02912. *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 14, 2011)

1069-60-113 **Fabrice Baudoin*** (fbaudoin@math.purdue.edu), Department of Mathematics Purdue University, 150 N. University Street, West Lafayette, IN 47906. *Modeling weak anticipations in a financial market.*

Financial markets obviously have asymmetry of information. That is, there are different type of traders whose behavior is induced by different types of information that they possess. Let us consider a "small" investor who trades in a arbitrage free financial market so as to maximize the expected utility of his wealth at a given time horizon. We assume that he possesses extra information about the future price of a stock. Our basic question is: What is the value of this information ? (Received January 18, 2011)

1069-60-122 **Kristin E Jehring*** (kjehring@saintmarys.edu), Department of Mathematics, Saint Mary's College, Notre Dame, IN 46556. *Harmonic Functions on Walsh's Brownian Motion.* Preliminary report.

We examine a variation of 2-dimensional Brownian motion introduced in 1978 by Walsh. Walsh's Brownian motion can be described as a Brownian motion on the spokes of a (rimless) bicycle wheel. We will construct the process by randomly assigning angles to excursions of a reflecting Brownian motion from 0. With this construction we see that Walsh's Brownian motion in the plane behaves like 1-dimensional Brownian motion away from the origin. Taking advantage of this similarity, we provide a characterization of harmonic functions for the process as linear functions on the rays that satisfy a slope-averaging property. We classify superharmonic functions as concave functions on the rays with some extra conditions. We generalize the state space to consider a process on any connected, locally finite graph obtained by gluing a number of Walsh's Brownian motion processes together. In this generalized situation, we also classify harmonic functions. We introduce a Markov chain associated to Walsh's Brownian motion on a graph and explore the relationship between the two processes. We address the reversibility of the process and derive the Dirichlet form of the reversible Walsh's Brownian motion on a graph. (Received January 19, 2011)

1069-60-130 **Ao Chen** (aochen2@illinois.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, Urbana, IL 61801, **Liming Feng*** (fenglm@illinois.edu), Dept of Industrial & Enterprise Systems Engr, University of Illinois at Urbana-Champaign, Urbana, IL 61801, and **Renming Song** (rsong@math.uiuc.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, Urbana, IL 61801. *Monitoring error of the supremum of a Lévy process.*

We derive asymptotic expansions for the monitoring error of the supremum of some Lévy processes that are commonly used in financial modeling. The monitoring error is measured by the expected difference between the continuously monitored supremum and evenly monitored discrete maximum of the Lévy process on a finite horizon. Full expansions for normal jump diffusion processes as well as normal inverse Gaussian processes will be shown. The case for more general Lévy processes will be discussed. In the normal jump diffusion case, the coefficients are related to the value of the Riemann zeta function at 1/2, a well known fact that has been observed for Brownian motion in the applied probability and mathematical finance literatures. (Received January 20, 2011)

1069-60-143 **Geoffrey R Harris*** (gharris@stuart.iit.edu), Stuart School of Business, 565 W. Adams St., Chicago, IL 60661, and **Tao L Wu**. *Valuation of Interest Rate Derivatives under Credit Risk and Illiquidity.*

During and after the credit crisis of 2007-2009, the relative prices of interest rate derivative contracts exhibited large deviations from the predictions of standard arbitrage pricing theory. These violations lead to the failure of many basic techniques that have been traditionally applied in fixed income modeling and pricing, such as yield curve bootstrapping. We introduce four different stochastic models of credit risk and liquidity, which make specific predictions of how these pricing deviations depend on the maturity of the contracts and the tenor of the underlying LIBOR rates. We then compare these predictions to empirical observations of the relative values of different forward rate agreements. (Received January 20, 2011)

1069-60-165 **Hongzhong Zhang** (hz2244@columbia.edu), 1255 Amsterdam ave, Rm 1010, New York, NY 10027, and **Olympia Hadjiliadis*** (ohadjiliadis@brooklyn.cuny.edu), 365 fifth ave, rm 4214, New York, NY 10016. *Market crashes through the drawdown and its speed (Part I).*

This abstract is the first in a sequence of two. In the first part we present a way to quantify market crashes through two cleverly chosen random variables, while in the second we study their probabilistic behavior. The first random variable is the drawdown of an asset and the second is the speed at which a drawdown is realized. Drawdowns measure the first time the current drop of an investor's wealth from its historical maximum reaches a pre-specified level. They are thus measures of risk which are widely used in financial risk management. Due to their path-dependent nature they can also be used as indicators of market crashes. Yet, in order to characterize the severity of a market crash one needs to take into account the speed at which it occurs. In order to capture this speed, we consider the last reset of the maximum of the underlying preceding the drawdown. We now propose the difference of the time of the drawdown to the last reset of the maximum preceding the drawdown as well as other measures related to this difference as possible measures of the speed of a market crash. An investor interested in insurance against a market crash could be interested in purchasing options related to the drawdown and its speed. This gives rise to the question of pricing such contracts. (Received January 21, 2011)

1069-60-166 **Hongzhong Zhang*** (hz2244@columbia.edu), 1255 Amstredam ave, Rm1010, New York, NY 10027, and **Olympia Hadjiliadis** (ohadjiliadis@brooklyn.cuny.edu), 365 fifth ave, Rm 4214, New York, NY 10016. *Market crashes through the drawdown and its speed (Part II).*

This is the second part in the sequence of two abstracts. Here, we address the problem of pricing insurance based on the drawdown and its speed. We consider the difference between the drawdown and the last reset of the maximum preceding the drawdown as the speed of the drawdown. We study the probabilistic behavior of the drawdown and its speed under general diffusion dynamics.In particular, we derive the joint Laplace transform of the speed of market crash, the last visit time of the maximum of a process preceding the drawdown and the maximum of the process under general diffusion dynamics. This derivation is achieved by decomposing the path to before and after the last reset of the maximum preceding the drawdown. A key observation in our derivations is that the path before the last reset of the maximum and the path after conditional on the level of the process at the last rest of the maximum before the drawdown are in fact independent. An important tool used in our derivations is the progressive enlargement of filtrations, which is used in order to turn the last reset of the maximum preceding the drawdown (an honest time) into a stopping time. We finally develop explicit formulas in the special cases of a drifted Brownian motion and the constant elasticity of variance model. (Received January 21, 2011)

1069-60-214 **José E Figueroa-López*** (figueroa@stat.purdue.edu), Department of Statistics, Purdue University, 250 N. University Street, West Lafayette, IN 47907, and **Martin Forde** (Martin.Forde@dcu.ie), Department of Mathematical Sciences, Dublin City University, Dublin 9, Glasnevin , Ireland. *The small-maturity smile for exponential Lévy models.*

We derive a small-time expansion for out-of-the-money call options under an exponential Lévy model, using a small-time expansion for the distribution functions of Lévy processes, combined with a change of numéraire via the Esscher transform. Using this result, we derive a small-time expansion for the implied volatility and illustrate its numerical performance. Our results are also extended to a class of time-changed Lévy models which exhibit volatility clustering. (Received January 24, 2011)

1069-60-244 **Rodrigo Rodriguez*** (rrodrig8@iit.edu), Engineering 1 Building, 10 West 32nd Street, Chicago, IL 60616, **Tomasz Bielecki** (bielecki@iit.edu), Engineering 1 Building, 10 West 32nd Street, Chicago, IL 60616, and **Igor Cialenco** (igor@math.iit.edu), Engineering 1 Building, 10 West 32nd Street, Chicago, IL 60616. *Pricing and Arbitrage in Markets with Transaction Costs.*

We study arbitrage in discrete-time markets where trading is subject to transaction costs. We show that there is no arbitrage if and only if there exists an equivalent probability measure under which the ask price process is a submartingale and the bid price process is a supermartingale. We compare our results to ones in existing literature, in particular to Jouini and Kallal 1995. (Received January 24, 2011)

1069-60-245 **Ismail Iyigunler*** (iiyigunl@iit.edu), Illinois Institute of Technology, Applied Mathematics Office, E 1 Building, 10 West 32nd Street, Chicago, IL 60616, and **Tomasz Bielecki** (igor@math.iit.edu) and **Igor Cialenco** (igor@math.iit.edu). *Counterparty Risk and the Impact of Collateralization in CDS Contracts.*

We analyze the counterparty risk embedded in CDS contracts, in presence of a bilateral margin agreement. First, we investigate the pricing of collateralized counterparty risk and deduce the bilateral Credit Valuation Adjustment (CVA), unilateral Credit Valuation Adjustment (UCVA) and Debt Valuation Adjustment (DVA). We propose a model for the collateral by incorporating all related factors such as the thresholds, haircuts and margin period of risk. We derive the dynamics of the bilateral CVA in a general form with related jump martingales. We also introduce the Spread Value Adjustment (SVA) indicating the counterparty risk adjusted credit spread. Counterparty risky and the counterparty risk-free spread dynamics are derived and the dynamics of the SVA is found as a consequence. We derive the relevant formulas for the valuation of the credit exposures such as Potential Future Exposure (PFE), Expected Positive Exposure (EPE) and Expected Negative Exposure (ENE). We finally employ a multivariate Markovian model for default intensities and illustrate our findings with numerical results. (Received January 24, 2011)

1069-60-254 **Zhao Zhang*** (zzhang35@iit.edu), 10 West 32nd Street, Room 208, Engineering 1 Building, Chicago, IL 60616, and **Tomasz Bielecki** and **Igor Cialenco**. *New Dynamic Performance Measures.*

We create a new framework to study coherent acceptability indices (a special class of performance measures) in a dynamic setup. We give a duality representation between dynamic coherent risk measures and dynamic coherent acceptability indices. Consequently, in the vein of the mainstream research on risk measures, we prove a representation theorem for such risk measures. Finally we provide a special construction of dynamic coherent acceptability indices, and discuss some explicit examples. (Received January 24, 2011)

62 ► Statistics

1069-62-321 **Glenn Tesler***, University of California, San Diego, Department of Mathematics, 9500 Gilman Dr., #0112, La Jolla, CA 92093-0112. *A decomposition of the Pearson X^2 statistic, with applications to pairwise gene interactions.*

Recent technological advances have made it feasible to conduct genome-wide scans in large populations to find genetic markers for common diseases and other traits. However, analyzing the data for assocations between traits and combinations of multiple markers is computationally challenging. Data has the form of an $n \times m$ table (n individuals, m markers, and a finite number of values allowed in each cell, such as one of 2 haplotypes or one of 3 genotypes). We study a transformation of this table and a decomposition of the Pearson X^2 statistic for a contingency table by Irwin (1949) that allows us to efficiently cluster together highly correlated markers. The central idea is a mathematical transformation that maps statistical correlation between locus pairs to distance between two points in a Euclidean space. This enables the use of geometric properties to identify proximal points (correlated locus pairs), without testing each pair explicitly.

This work is joint with Vineet Bafna, Dumitru Brinza, and Matthew Schultz at the University of California, San Diego. (Received January 25, 2011)

65 ► Numerical analysis

1069-65-7 **Lawrence F Shampine*** (lfshampine@aol.com), 1204 Chesterton Dr., Richardson, TX 75080. *Integrating Oscillatory Functions in MATLAB.*

When ω is large, the integrand of $\int_a^b f(x)\, e^{i\omega x}\, dx$ is highly oscillatory and conventional quadrature programs are ineffective. A new method based on a smooth cubic spline is implemented in a MATLAB program `osc` that is both easy to use and effective for large ω. Other methods are used in the program to deal effectively with small ω. Because the implementation of the basic method is adaptive, the program deals comparatively well with $f(x)$ that have peaks. With the assistance of another method, the program is able to deal effectively with $f(x)$ that have a moderate singularity at one or both ends of $[a, b]$. The algorithms and user interface of `osc` exploit the capabilities of the MATLAB computing environment. (Received September 20, 2010)

1069-65-8 **Jue Yan*** (jyan@iastate.edu), 396 carver Hall, Department of Mathematics, Iowa State University, Ames, IA 50010. *A Local Discontinuous Galerkin Method for directly solving Hamilton-Jacobi Equations.*

In this paper we propose a new local discontinuous Galerkin method to directly solve Hamilton-Jacobi equations. The scheme is a natural extension of the monotone scheme. For the linear case with constant coefficients, the method is equivalent to the discontinuous Galerkin method for conservation laws. Thus, stability and error analysis are obtained under the framework of conservation laws. For both convex and noneconvex Hamiltonian, optimal (k+1)-th order of accuracy for smooth solutions are obtained with piecewise k-th order polynomial approximations. The scheme is numerically tested on a variety of one and two dimensional problems. The method works well to capture sharp corners (discontinuous derivatives) and have the solution converges to the viscosity solution. (Received September 27, 2010)

1069-65-12 **James A Rossmanith*** (rossmani@math.wisc.edu), 480 Lincoln Drive, Madison, WI 53706. *Discontinuous Galerkin based constrained transport schemes for ideal MHD.*

Standard shock-capturing numerical methods fail to give accurate solutions to the equations of magnetohydrodynamics (MHD). The essential reason for this failure is that by ignoring the divergence-free constraint on the magnetic fi eld, these methods can be shown to be entropy unstable. In this talk we will briefly review the entropy stability theorem for discontinuous Galerkin (DG) methods. We will then present a class of constrained transport (CT) methods that we will give both stable and accurate results on several test cases. The proposed CT approach can be viewed as a predictor-corrector method, where an approximate magnetic field is first predicted by a standard DG method, and then corrected through the use of a magnetic potential. We will also briefly describe a new class of limiters that is used in this work to stabilize the DG-FEM discretization. (Received November 09, 2010)

1069-65-14 **Mahboub Baccouch*** (mbaccouch@unomaha.edu), DSC 233, 6001 dodge st., omaha, NE 68182. *The Local Discontinuous Galerkin method for elliptic problems.*

We present a new LDG method for two-dimensional diffusion problems and investigate its convergence properties. Numerical computations suggest that the proposed method yield $O(h^{p+1})$ optimal $\mathcal{L}^2$ convergence rates and $O(h^{p+2})$ superconvergent solutions at Radau points. More precisely, a local error analysis reveals that the leading term of the LDG error for a p-degree discontinuous finite element solution is spanned by two $(p+1)$-degree right-Radau polynomials in the x and y directions. Thus, p-degree LDG solutions are superconvergent at right-Radau points obtained as a tensor product of the shifted roots of the $(p+1)$-degree right-Radau polynomial. For $p = 1$, we discover that the first component of the solution's gradient is $O(h^3)$ superconvergent at tensor product of the roots of the quadratic left-Radau polynomial in x and right-Radau polynomial in y while the second component is superconvergent at the tensor product of the roots of the quadratic right-Radau polynomial in x and left-Radau polynomial in y. We use these superconvergence results to construct simple, efficient and asymptotically correct *a posteriori* error estimates. Several numerical simulations are performed to validate the theory. (Received November 11, 2010)

1069-65-17 **Jichun Li*** (jichun@unlv.nevada.edu), Dept of Mathematical Sciences, 4505 Maryland PKWY, Las Vegas, NV 89154-4020. *Recent advances in finite element study of Maxwell's equations in metamaterials.*

Since the successful demonstration of double negative metamaterials in 2000, numerical simulation of metamaterials plays a very important role in searching for new constructions and applications of metamaterials.

In this talk, I will present several time-domain finite element methods recently developed for solving the Maxwell's equations in metamaterials. Both error analysis and numerical implementation of the algorithms will

be covered in the talk. Finally, some interesting numerical results will be presented. (Received November 15, 2010)

1069-65-32 **Mohamed Badawy*** (mbadawy@math.ku.edu), Department of Mathematics, 405 Snow hall, 1460 Jayhawk blvd., Lawrence, KS 66045, and **Erik Van Vleck**. *Perturbation theory for the approximation of stability spectra by QR methods for sequences of linear operators on a Hilbert Space.*

In this talk, we develop a perturbation analysis for stability spectra (Lyapunov exponents and Sacker-Sell spectrum) for products of operators on a Hilbert space based upon the discrete QR technique. Error bounds are obtained in both the integrally separated and non-integrally separated cases and for both real and complex valued operators. We illustrate our results using a linear parabolic partial differential equation in which the strength of the integral separation determines the sensitivity of the stability spectra to perturbation. (Received December 07, 2010)

1069-65-36 **Glenn R. Luecke*** (grl@iastate.edu), 291 Durham Center, Iowa State University, Ames, IA 50011. *High Performance Computing & Numerical Analysis.*

This talk will present an overview of current hardware and software trends in high performance computing technology and their impact on numerical analysis. Topics will include shared memory parallelization, distributed memory parallelization, hybrid parallelization and parallelization using GPUs. (Received December 09, 2010)

1069-65-38 **Erik S Van Vleck*** (erikvv@ku.edu), Deparment of Mathematics, University of Kansas, Lawrence, KS 66045. *Multi-Dimensional Stability of Traveling Waves for Spatially Discrete Bistable Reaction-Diffusion Equations.*

In this talk we consider the orbital stability of traveling waves for spatially discrete or discretized bistable reaction-diffusion equations. We present background on the difficulty in the spatially discrete case and the relationship to the question of multi-dimensional stability for the corresponding PDE. Two approaches are considered, one in which exponential stability is obtained under certain conditions and another more generally applicable approach that leads to asymptotic stability with an algebraic rate. We will discuss the dependence of the results on the direction of propagation. (Received December 10, 2010)

1069-65-39 **Barbara Zubik-Kowal*** (zubik@math.boisestate.edu), Department of Mathematics, Boise State University, 1910 University Drive, Boise, ID 83725. *Numerical solutions and simulations for the analysis of mathematical models of cancer growth.*

Animal models provide important insight into the development of cancer research. Mice injected with cancer cells from human tumor samples, allow to develop natural interactions between cancer cells and surrounding tissues to test tumor progression *in vivo* and take into account the additional factor of the immune system response. On the other hand, mathematical models have recently demonstrated their enormous potential to describe the growth of tumor cells and their response to therapy.

In this talk, we investigate a system of differential equations modeled with unknown parameters and construct numerical solutions in order to compare them with laboratory data and to estimate the parameter values for the mathematical model. We utilize previously developed animal models, which provide valuable sources of experimental data. It is shown that the constructed numerical solutions of the resulting model equations formulated with the estimated parameter values correspond to the laboratory data and illustrate a good agreement with *in vivo* growth of tumors thus demonstrating the potential to decrease the numbers of the laboratory experiments and partially replace them by numerical experiments describing the behavior of simulated tumors. (Received December 10, 2010)

1069-65-42 **Raymond J. Spiteri*** (spiteri@cs.usask.ca), Department of Computer Science, 176 Thorvaldson Building, 110 Science Place, Saskatoon, SK S7N5C9, Canada, and **Megan E. Lewis**. *Stiffness analysis of cardiac cell models.*

Mathematical models of electric activity in cardiac tissue are often based on ordinary differential equations that describe the ionic currents at the cell level coupled with partial differential equations that describe how the electricity flows at the tissue level. Because of the high resolutions required, the physiological accuracy of data produced from simulations of tissue-scale models is often limited by the efficiency of the numerical method. Moreover, the intricate, stiff, and nonlinear nature of the cell models makes them challenging to solve numerically. Accordingly, no single numerical method can be expected to perform well on every model. In this talk, I describe a stiffness analysis of 39 verified cardiac cell models from the CellML repository and show how it can lead to the construction of new and highly efficient numerical methods for their solution. (Received December 11, 2010)

1069-65-43 **Yingjie Liu*** (yingjie@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332. *Hierarchical Reconstruction for Central Schemes and Central DG on Overlapping Cells.*

The central scheme of Nessyahu and Tadmor (JCP 1990) does not use any Riemann solver for solving hyperbolic conservation laws and related equations. The recently developed central scheme and central DG on overlapping cells use overlapping cells (dual cells) at the same discrete time level, and introduce a technique to eliminate the O(1/Delta t) dependence of the dissipation. The overlapping cell representation of the solution also provides new possibilities for reconstruction and limiting, and finds its usefulness in the computation of MHD equations. I will discuss the recently developed hierarchical reconstruction technique on overlapping cells for the limiting of these methods, and report our newest results. This technique does not use any characteristic decomposition, is compact and can be formulated on unstructured meshes naturally. It decomposes the job of limiting a high degree polynomial defined in a cell into a series of smaller jobs, each of which only involves the non-oscillatory reconstruction of a linear polynomial from cell averages. The talk incorporates several collaborated works with C.-W. Shu, E. Tadmor, Z.-L. Xu and M.-P. Zhang. (Received December 13, 2010)

1069-65-47 **Dexuan Xie*** (dxie@uwm.edu), Department of Mathematical Science, University of Wisconsin-Milwaukee, Milwaukee, WI 53201. *Fast finite element solver development for a nonlocal dielectric continuum model.*

The nonlocal continuum dielectric model is an important extension of the classical Poisson dielectric model but much more expensive to be solved numerically. In this talk, I will first introduce one commonly-used nonlocal dielectric model and demonstrate its great promise in the calculation of free energies with a much higher accuracy than the Poisson model. I then will report some recent results we made on the finite element analysis and fast solver development for this model. Remarkably, we split the solution of this model as a sum of the two functions that satisfy one Helmholtz equation and one Poisson equation, respectively. This makes it possible to develop fast solvers for nonlocal dielectric modeling. This project is supported in part by NSF grant #DMS-0921004. (Received December 21, 2010)

1069-65-59 **Fei Wang** and **Weimin Han*** (weimin-han@uiwoa.edu), 14 MLH, Iowa City, IA 52242, and **Xiaoliang Cheng**. *Discontinuous Galerkin Methods for Solving the Signorini Problem.*

We introduce and study several discontinuous Galerkin methods (DGMs) for solving the Signorini problem. A unified error analysis is provided for the methods. The error estimates are of optimal order for linear elements. A numerical example is reported to illustrate numerical convergence orders. (Received January 10, 2011)

1069-65-61 **Zhilin Li*** (zhilin@math.ncsu.edu), Center for Research in Scientific Computation, and Department of Mathematics, North Carolina State University, Raleigh, NC 27695. *Recent Progress of IIM and applications to CFD problems with free boundaries/moving interfaces.*

The Immersed Interface Method (IIM) is an efficient numerical method for interface, free boundary/moving interface problems, and problems on irregular domains. The IIM is a sharp interface method that enforces jump conditions either exactly or approximately. In this talk, I will summarize some recent advances of the IIM, particularly, the augmented approach and its application to incompressible Stokes and Navier Stokes equations with singular sources, discontinuous viscosity, irregular domains, and free boundary and moving interfaces using the augmented IIM. Particularly, I will explain the approach for incompressible (or inextensible) interfaces) in incompressible flows. Most previous work has been done using Stokes equations model by the boundary integral method. The problem is essentially an inverse problem to find an unknown surface tension such that the incompressible condition is satisfied. Geometrically, both the area and length of the interface has to be preserved. In our work, the method can be applied to both the Stokes or Navier-Stokes equations. We propose a new way to enforce the pressure jump conditions. Some new numerical simulation results will also be presented. (Received January 11, 2011)

1069-65-72 **Laurent O. Jay*** (laurent-jay@uiowa.edu), Department of Mathematics, 14 MacLean Hall, The University of Iowa, Iowa City, IA 52242-1419, and **Manuel Calvo** (calvo@unizar.es), Departamento de Matem'atica Aplicada, Pza. San Francisco s/n, Universidad de Zaragoza, 50009 Zaragoza, Spain. *A definition of stiffness for initial value problems for ODEs.* Preliminary report.

Almost sixty years after the pioneering paper of Curtiss and Hirschfelder (1952) there is still no widely accepted precise definition of stiffness. In this talk we propose a definition of stiffness for initial value problems for ODEs. The strong damping of some infinitesimal perturbations to the solution is seen as the source of the various stiffness phenomena observed and described in the literature. We isolate the concept of stiffness from considerations of

smoothness or transient behavior of solutions and also from any class of numerical integration methods. From our point of view stiffness is a local concept in time and state and depending on a certain time-scale of interest. The ingredients in our definition of stiffness are given by the system of ODEs $\frac{d}{dt}x = f(t,x)$, a current time value $t = a$, a certain time-scale h, and a solution $x(t)$ on the interval $[a, a+h]$. The strongest damping of infinitesimal perturbations to the solution $x(t)$ occurring within the time interval of interest $[a, a+h]$ is defined as the stiffness strength. When the stiffness strength falls below a certain threshold we consider the solution $x(t)$ to be stiff from $t = a$ on the time-scale h. (Received January 13, 2011)

1069-65-85 **Fatih Celiker*** (celiker@math.wayne.edu), Wayne State University, Department of Mathematics, 656 W. Kirby, Detroit, MI 48187, and **Bernardo Cockburn** and **Ke Shi**. *Hybridizable discontinuous Galerkin methods for biharmonic problems.*

We introduce a new HDG method for solving the 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 hybridized 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. Numerical experiments 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. (Received January 14, 2011)

1069-65-110 **Jay Gopalakrishnan** and **Johnny Guzman***, johnny_guzman@brown.edu. *A family of non-conforming, symmetric mixed methods for linear elasticity.*

In this talk we present a family of symmetric, non-conforming mixed methods for linear elasticity. We consider two and three dimensional domains which are triangulated using simplices. The main tool is a new set of degrees of freedom for symmetric matrix fields with polynomial entries. In addition, we discuss a new and simple proof of the dimension of matrix fields with polynomial entries defined on a tetrahedron which are divergence free and have normal traces zero. (Received January 18, 2011)

1069-65-153 **Kamran Kazmi*** (kazmis@uwosh.edu), Mathematics Department, University of Wisconsin Oshkosh, 800 Algoma Blvd, Oshkosh, WI 54901, and **Mikael Barboteu**, **Weimin Han** and **Mircea Sofonea**. *Numerical Analysis of History-dependent Quasivariational Inequalities with Applications in Contact Mechanics.*

A new class of history-dependent quasivariational inequalities was recently studied in a paper by Sofonea and Matei. In this talk, we give numerical analysis of these quasivariational inequalities. We introduce temporally semi-discrete and fully discrete schemes for the numerical approximation of the inequalities and derive some error estimates. We then apply these results to a quasistatic frictional contact problem. (Received January 21, 2011)

1069-65-154 **Greg Fasshauer*** (fasshauer@iit.edu), Chicago, IL 60564, and **Mike McCourt**. *Stable Evaluation of Gaussian RBF Interpolants.*

We present a new way to compute and evaluate Gaussian radial basis function interpolants in a stable way also for small values of the shape parameter, i.e., for "flat" kernels. This work is motivated by the fundamental ideas proposed earlier by Bengt Fornberg and his co-workers. However, following Mercer's theorem, an $L_2(\mathbb{R}^d, \rho)$-orthonormal expansion of the Gaussian kernel allows us to come up with an algorithm that is simpler than the one proposed by Fornberg, Larsson and Flyer and that is applicable in arbitrary space dimensions d. (Received January 21, 2011)

1069-65-179 **Hailiang Liu**, **Zhongming Wang*** (z2wang@math.ucsd.edu) and **Rodney Fox**. *A level set approach for dilute non-collisional fluid-particle flows.*

Gas-particle and other dispersed-phase flows can be described by a kinetic equation containing terms for spatial transport, acceleration, and particle processes (such as evaporation or collisions). However, computing the dispersed velocity is a challenging task due to the large number of independent variables. A level set approach for computing dilute fluid-particle flows is presented. We will consider the sprays governed by the Williams kinetic equation with the initial distribution of the form $\sum_{i=1}^{N} \rho_i(x)\delta(\xi - u_i(x))$. The dispersed velocity is described as the zero level set of a smooth function, which satisfies a transport equation. This together with the density weight recovers the particle distribution at any time. Moments of any desired order can be evaluated by a quadrature formula involving the level set function and the density weight. It is shown that the method can successfully handle highly non-equilibrium flows (e.g. impinging particle jets, jet crossing, particle rebound off walls, finite Stokes number flows). (Received January 22, 2011)

1069-65-220 **Jeongho Ahn*** (jeongho.ahn@mathstat.astate.edu), Department of Mathematics & Statistics, Arkansas State University, P.O. Box 70, State University, AR 72467. *Vibrations of a Gao beam with two stops.*

We consider a contact model of a viscoelastic (Kelvin-Voigt type) Gao beam in which its left end is rigidly attached and its right end satisfies Signorini's contact conditions. The existence of solutions is proved and numerical solutions are computed by using the time discretization over the time interval and Galerkin approximation over the spacial domain. One of our major concerns is to investigate conservation of energy (or energy balance), which will be justified theoretically and numerically. We note that the similar contact model has been previously studied by Andrew *et al* but there is no numerical computation in their work. (Received January 24, 2011)

1069-65-222 **Hailiang Liu**, Ames, IA 50010, and **Hui YU*** (legendyu@iastate.edu), Ames, IA 50010. *AN ENTROPY SATISFYING METHOD FOR THE FOKKER-PLANCK EQUATION OF FENE DUMBBELL MODEL FOR POLYMERS.* Preliminary report.

In this paper, we present a novel entropy satisfying method to solve the Fokker-Planck equation of FENE dumbbell model for polymers. The method applies to both one dimensional and two-dimensional models with deformation induced by homogeneous fluids. Both semi-discrete and fully discrete schemes satisfy all three desired properties: i) mass conservation, ii) positivity preserving, and iii) entropy diminishing in time. These ensure that the computed solution is a probability density, and the solution converges to equilibrium as time evolves. Zero-flux at boundary is naturally incorporated, and boundary behavior is resolved sharply. Both one and two-dimensional numerical results are provided to demonstrate the good qualities of the scheme, as well as effects of some canonical homogeneous flows. (Received January 24, 2011)

1069-65-290 **Jing Shi*** (jshi@math.wayne.edu), Department of Mathematics, Wayne State University, Detroit, MI 48202. *Numerical methods for Stochastic Differential Equations of Levy Jump-Diffusion type.* Preliminary report.

In this talk we shall discuss some numerical discretization of a class of stochastic differential equations of Levy jump-diffusion type. Higher order strong approximations are studied. (Received January 25, 2011)

1069-65-310 **Sheng Zhang*** (szhang@wayne.edu), Department of Mathematics, Wayne State University, Detroit, MI 48202. *Some uniformly accurate discontinuous Galerkin methods for thin elastic shells.* Preliminary report.

We present some finite element methods for thin elastic shells. The methods are derived in the discontinuous Galerkin approach. We show the uniform accuracy of the numerical schemes when the shell is getting thinner and thinner. (Received January 25, 2011)

1069-65-314 **Andreas Kleefeld** (kleefeld@tu-cottbus.de) and **Tzu-Chu Lin*** (lin@uwm.edu). *The numerical solution of Helmholtz's equation for the exterior Neumann problem in three dimensions.* Preliminary report.

A numerical method is described for the solution of the exterior Neumann problem for the Helmholtz equation in three dimensions. The problem is reformulated as a Fredholm integral equation of the second kind, based on an approach of Panich. This is numerically solved using a global Galerkin method based on spherical harmonics. A grading parameter, introduced recently by Atkinson for numerical integration, is used to improve the accuracy. (Received January 25, 2011)

1069-65-335 **Roy H. Stogner** (roystgnr@ices.utexas.edu), Institute for Computational Engineering and, Sciences, University of Texas at Austin, Austin, TX 78712, **Graham F Carey** (carey@cfdlab.ae.utexas.edu), Institute for Computational Engineering and, Sciences, University of Texas at Austin, Austin, TX 78712, and **S. Sum Chow*** (schow@math.byu.edu), Department of Mahtematics, Brigham Young university, Provo, UT 84602. *Numerical approximation of generalized Newtonian fluids using composite macroelements.*

In this talk we examine the use of strong divergence-free basis derived from composite macro-element bases in viscous flow and transport problems. Due to the constrained composite nature of the underlying elements, the construction of basis functions is not straightforward and the development of parallel adaptive formulation is consequently more complex than that encountered with standard element types. We will describe the theoretical advantage of using the PSH divergence free elements in generalized Newtonian incompressible viscous flow and discuss some numerical issues involving PSH and HCT divergence-free elements. (Received January 25, 2011)

1069-65-342 **Scott J. Small*** (scott-small@uiowa.edu), 14 Maclean Hall, Iowa City, IA 52241. *A Class of Numerical Methods for Solving Mechanical Systems with Mixed Holonomic and Nonholonomic Constraints.*

A class of Runge-Kutta style solvers for differential-algebraic systems with index 2 constraints was proposed by Murua in 1996. We present an extension of these solvers to systems with mixed index 2 and index 3 constraints. We focus in particular on Lagrangian and Hamiltonian systems arising in classical mechanics. In this setting, the index 2 and index 3 constraints are referred to as nonholonomic and holonomic constraints, respectively. Conditions ensuring the local existence and uniqueness of a numerical solution are given. Numerical experiments demonstrating the order of these methods are also presented. (Received January 25, 2011)

1069-65-357 **HAOMIN ZHOU*** (hmzhou@math.gatech.edu), School of Mathematics, Georgia Tech, 686 Cherry Street, Atlanta, GA 30332. *Efficient Numerical Methods for Forward and Inverse Stochastic Helmholtz Equations and Applications.*

In the first part of this presentation, we give a stochastic model for general spatially incoherent sources with applications in photonic crystal. The model naturally incorporates the incoherent property and leads to stochastic Maxwell equations. We also propose a fast numerical method based on Wiener Chaos Expansions (WCE). In the applications of photonic crystal, the new methods can achieve 2 order of magnitude faster computation time over the standard method. In the second part, We study the inverse source problem for Helmholtz equation with a spatially random source function. We propose a novel and efficient strategy, which only uses fast fourier transforms (FFT), to reconstruct the statistical properties of the random source function from measurements at one boundary point.(This talk is based on collected research results collaborating with A. Adibi, M. Badiei, G. Bao, S.-N. Chow and P. Li). (Received January 25, 2011)

68 ► Computer science

1069-68-322 **Kishore Kothapalli** and **Sriram V Pemmaraju*** (sriram-pemmaraju@uiowa.edu), 101G McLean Hall, The University of Iowa, Department of Computer Science, Iowa City, IA 52242. *Quickly Coloring Graphs with Small Arboricity.*

This paper considers the question of how may colors a distributed graph coloring algorithm would need to use if it had only k rounds available, for any positive integer k. In our main result, we present an algorithm that runs in $O(k)$ rounds for any $k = \Omega(\log \log n)$, and uses $O(a \cdot n^{1/k})$ colors to color a graph with arboricity a. This result is optimal since the palette size matches the lower bound of Barenboim and Elkin (*PODC 2008*). This result is achieved via the use of several new results developed in this paper on coloring graphs whose edges have been acyclically oriented. For example, suppose that G is an n-vertex, acyclically oriented graph with maximum out-degree Δ_o. We present an algorithm that, for any $k \geq 2 \log \log n$, runs in $O(k)$ rounds on G to produce an (i) $O(\Delta_o)$-coloring when $\Delta_o \in \Omega(kn^{2/k^2} \log^{1+1/k} n)$ and an (ii) $O(\Delta_o \cdot n^{2/k^2})$-coloring when $\Delta_o \in \Omega(k \log^{1+1/k} n)$. These results are useful in any setting where it is possible efficiently compute acyclic orientations of a graph with $\Delta_o << \Delta$. We derive non-trivial bounds on the palette size even when $k < 2 \log \log n$. (Received January 25, 2011)

74 ► Mechanics of deformable solids

1069-74-50 **Mircea Sofonea*** (sofonea@univ-perp.fr), Laboratoire LAMPS, University of Perpignan, 52 Avenue Paul Alduy, 66100 Perpignan, France. *History-dependent Quasivariational Inequalities Arising in Contact Mechanics.*

We consider a class of quasivariational inequalities arising in a large number of mathematical models which describe quasistatic processes of contact between a deformable body and an obstacle, the so-called foundation. The novelty arise in the special structure of these inequalities which involve a history-dependent term as well as in the fact that the inequalities are formulated on an unbounded interval of time. We prove an existence and uniqueness result of the solution, then we complete it with a regularity result. The proofs are based on arguments of monotonicity, convexity, and fixed point. Further, we consider a quasistatic frictional contact problem in which the material's behavior is modeled with a viscoelastic constitutive law, the contact is bilateral, and the friction is described with a slip-rate version of Coulomb's law. We prove that this problem cast in the abstract setting of history-dependent quasivariational inequalities, with a convenient choice of spaces and operators. Then we apply the abstract results in order to prove the unique weak solvability of this contact problem and to describe the regularity of the weak solution, as well. (Received January 06, 2011)

1069-74-53 **Mikaël Barboteu*** (barboteu@univ-perp.fr), Universite de Perpignan Via Domitia, Batiment B3, case courrier 12, 52, Avenue Paul Alduy, 66860 Perpignan, France. *Numerical Solution of a Quasistatic Frictional Contact Problem.*

We consider a quasistatic frictional contact problem in which the material's behavior is modeled with a viscoelastic constitutive law, the contact is bilateral, and the friction is described with a slip-rate version of Coulomb's law. The variational formulation of the problem is in a form of a quasivariational inequalitiy for the velocity field. The unique weak solvability of the problem as well as its numerical analysis are provided by general result on history-dependent quasivariational inequalities. In the present work we focus on numerical simulations of the problem. To this end we first describe the numerical solution, which is based on an appropriate second order scheme for the discretization of the time derivatives combined with a specific iterative procedure used in order to take into account the slip-rate dependent friction law. Then we present some numerical examples which validate the theoretical error estimates obtained in the study of this problem. And, finally, we provide additional comments concerning the behavior of the solution. (Received January 06, 2011)

1069-74-84 **Kenneth L. Kuttler*** (klkuttle@math.byu.edu), Kenneth Kuttler, Department of Math., Brigham Young University, Provo, UT 84602, and **Purcell** and **Shillor**. *A contact problem for a Gao beam with a crack.*

This work studies and simulates the dynamics of a Gao beam that may come in contact with a reactive foundation, and which has an evolving symmetric edge crack. The problem is set as a variational inequality coupled with a differential equation for the evolution of the damage variable, which measures the severity of the crack. The existence of a local weak solution for the model is proved using approximations, result for abstract problems in Hilbert spaces, and a priori estimates. (Received January 14, 2011)

1069-74-140 **Meir Shillor*** (shillor@oakland.edu). *Recent Results on Dynamic Contact of a Gao Beam.*

The talk presents some of our recent mathematical and computational results on the dynamics of the nonlinear Gao beam that allows for the study of buckling when a sufficiently large traction is applied at one of the beam's ends. First, the model and the existence and uniqueness of the weak solution will be described, as well as a new result on the additional regularity of the solutions. Numerical simulations of the vibrations of the beam, in particular vibrations about a buckled state, will be shown. Such vibrations cannot happen in a linear beam, and they are the main motivation for the study of the Gao beam. Then, the analysis and simulations of the model when one end is constrained to move between two stops will be discussed. And, also, the vibrations of two beams with a Signorini type of coupling with two rigid stops will be mentioned. The model and its numerical simulations, when the oscillations are constrained by an obstacle under the beam, will be presented. This model takes into account the damage of the beam caused by the growth of a symmetric crack. Finally, we will mention briefly a new model for MEMS actuators that is under study. (Received January 20, 2011)

1069-74-176 **Robert Zalewski*** (robertzalewski@wp.pl), Narbutta 84 str., 02-524 Warsaw, Poland, and **Jerzy Bajkowski** (jba@simr.pw.edu.pl), Narbutta 84 str., 02-524 Warsaw, Poland. *Comparison of MR fluids and new granular structures in special conditions.* Preliminary report.

In this work we introduce a new controllable structure, somewhat similar to MR fluids, which is based on a granular material. Loose granular material is initially placed in a deformable hermetic sleeve (basically made of a soft polymer), equipped with a special valve. Then, the air is partially pumped out of the structure generating so called 'underpressure.' This change in the structure causes a considerable increase in its stiffness. Such granular structures, when high underpressure value is applied, exhibit typical properties of solid (semisolid) state. The magnitude of this change in stiffness is fully controlled by the range of the generated internal underpressure. Typical experimental results conducted for these materials and MR fluids are discussed in this paper. In the next steps of the research we plan to use such a structure to study dynamic and quasistatic contact. The modelling of the contact conditions will be of considerable interest. (Received January 22, 2011)

1069-74-201 **Marius Cocou*** (cocou@lma.cnrs-mrs.fr), Laboratory of Mechanics and Acoustics, C.N.R.S., 31 Chemin Joseph Aiguier, 13402 Marseille Cedex 20, France. *Analysis of a class of quasistatic Coulomb friction problems.*

This talk presents some existence results and approximation properties for a class of quasistatic unilateral contact problems with Coulomb friction law in elasticity. Using an implicit time discretization scheme, a mixed variational formulation of these problems is analyzed and the existence of corresponding solutions is established under appropriate assumptions on the coefficient of friction. Some interesting (im)penetrability properties of the

variational solutions and the relationship between these solutions and those of problems with classical Signorini's conditions are also presented. Finally, the extensions to more complex contact interaction laws, as, for example, the coupling between adhesion and friction, or to more general constitutive equations are discussed. (Received January 24, 2011)

1069-74-231 **David E Stewart*** (dstewart@math.uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52242, and **Wendt J Theodore** (wendt.theo@uwlax.edu), Department of Mathematics, University of Wisconsin, LaCrosse, LaCrosse, WI 54601. *A mixed displacement-velocity based formulation of elastic contact.*

The standard Signorini conditions for mechanical contact problems is based on the normal displacement of the elastic body on the boundary. The linearized form is

$$0 \leq \varphi(\mathbf{x}) - \mathbf{n}(\mathbf{x}) \cdot \mathbf{u}(t, \mathbf{x}) \perp N(t, \mathbf{x}) \geq 0.$$

Here φ is the "gap function" which is the normal distance from the undeformed body to the obstacle, and N is the normal contact force. Existence of solutions to impact problems of this type with Kelvin–Voigt viscoelasticity has been shown by various authors. Eck and Jarušek, however, have worked with the corresponding problem (with Coulomb friction included) with $\mathbf{u}$ replaced by $\partial\mathbf{u}/\partial t$ in the contact conditions, which unfortunately is not physically realistic. In order to obtain an intermediate model that is physically more realistic, we present a contact condition with $\mathbf{u}$ replaced by $\mathbf{u} + \beta\partial\mathbf{u}/\partial t$, β a positive constant. Solutions are shown to exist under some conditions, and ideas for using these results to advance the understanding of mechanical impact are presented. (Received January 24, 2011)

76 ► Fluid mechanics

1069-76-295 **Alexander Kurganov*** (kurganov@math.tulane.edu), Mathematics Department, Tulane University, 6823 St. Charles Ave., New Orleans, LA 70118, and **Michael Pollack** (mpollack@tulane.edu), Mathematics Department, Tulane University, 6823 St. Charles Ave., New Orleans, LA 70118. *Semi-Discrete Central-Upwind Schemes for Elasticity in Heterogeneous Media.*

I will present a new central-upwind scheme for nonlinear elasticity equations in a heterogeneous medium. Central-upwind schemes consist of three steps: reconstruction, evolution and projection onto the original grid. In our new method, the evolution is performed in the standard way by integrating the system over the space-time control volumes. However, the reconstruction and projection are performed in a special manner by taking into account the fact that the conservative variables (strain and momentum) are discontinuous across the material interfaces, while the flux variables (velocity and strain) are continuous there. The new reconstruction and projection procedures lead to the central-upwind scheme with extremely small numerical diffusion so that in long time calculations, the new scheme outperforms existing upwind alternatives. In addition, the proposed scheme can be made positivity preserving. To achieve this goal, the system is rewritten in terms of auxiliary variables and the local propagation speeds of the system are adjusted accordingly. Our numerical experiments demonstrate that the developed scheme is capable of accurately resolving waves with dispersive behavior that over a long period of time evolve into solitary waves while remaining nonnegative. (Received January 25, 2011)

1069-76-362 **Ying Wang** and **Chiu-Yen Kao*** (kao@math.ohio-state.edu). *CENTRAL SCHEMES FOR THE MODIFIED BUCKLEY-LEVERETT EQUATION.*

The focus of the present study is the modified Buckley-Leverett (MBL) equation describing two-phase flow in porous media. The MBL equation differs from the classical Buckley-Leverett (BL) equation by including a balanced diffusive-dispersive combination. The classical BL equation gives a monotone water saturation profile for any Riemann problem; on the contrast, when the dispersive parameter is large enough, the MBL equation delivers non-monotone water saturation profile for certain Riemann problems as suggested by the experimental observations. In this talk, we first show that the solution of the finite interval boundary value problem converges to that of the half-line problem for the MBL equation as the length of the interval goes to infinity. This result provides a justification for the use of the finite interval boundary value problem in numerical studies for the half line problem. Furthermore, we extend the classical central schemes for the hyperbolic conservation laws to solve the MBL equation which is of pseudo-parabolic type. Numerical results confirm the existence of non-monotone water saturation profiles consisting of constant states separated by shocks. (Received January 26, 2011)

78 ► Optics, electromagnetic theory

1069-78-60 **Peijun Li*** (lipeijun@math.purdue.edu), Department of Mathematics, Purdue University, West Lafayette, IN 47907. *An Inverse Random Source Scattering Problem in Inhomogeneous Media.*

In this talk, we consider the scattering problem for the one-dimensional stochastic Helmholtz equation in a slab of inhomogeneous medium, where the source function is driven by the Wiener process. To determine the random wave field, the direct problem is equivalently formulated as a two-point stochastic boundary value problem. This problem is shown to have pathwise existence and uniqueness of a solution. Furthermore, the solution is explicitly deduced with an integral representation by solving the two-point boundary value problem. Since the source and hence the radiated field are stochastic, the inverse problem is to reconstruct the statistical structure, such as the mean and the variance, of the source function from physically realizable measurements of the radiated field on the boundary point. Based on the constructed solution for the direct problem, integral equations are derived for the reconstruction formulas, which connect the mean and the variance of the random source to those of the measured field. Numerical examples will be presented to demonstrate the validity and effectiveness of the proposed method. (Received January 10, 2011)

81 ► Quantum theory

1069-81-190 **Rafael D. Benguria**, **Gonzalo Bley** and **Michael Loss*** (loss@math.gatech.edu), School of Mathematics, Georgia Tech, 686 Cherry Street, Atlanta, GA 30332-0160. *A new estimate on the indirect part of the Coulomb energy.*

In 1981 , Lieb and Oxford proved that the indirect part E_P of the Coulomb energy of a many particle wave function Ψ can be bounded from below by $-1.68 \int \rho(x)^{4/3} dx$ where $\rho(x)$ is the single particle density associated with Ψ. The constant was subsequently improved by Chan and Handy to 1.636 using numerical methods. In this talk I present a new estimate of the form

$$E_P \geq -C(\varepsilon) \int \rho(x)^{4/3} dx + \varepsilon(\rho^{1/2}, \sqrt{-\Delta}\rho^{1/2})$$

where, by choosing ε appropriately, $C(\varepsilon)$ can be as close as one likes to 1.46. This is joint work with Rafael Benguria and Gonzalo Bley. (Received January 23, 2011)

1069-81-247 **David Hasler*** (dghasler@wm.edu). *Wegner estimate and Anderson localization for random magnetic fields.*

We consider a two dimensional magnetic Schroedinger operator with a spatially stationary random magnetic field. We show a Wegner estimate, which can be used to prove localization at the bottom of the spectrum. This is joint work with L. Erdos. (Received January 24, 2011)

1069-81-292 **Richard G. Froese*** (rfroese@math.ubc.ca), Department of Mathematics, 1984 Mathematics Road, University of British Columbia, Vancouver, BC V6T 1Z2, Canada, and **Florina Halasan** and **David Hasler**. *Absolutely continuous spectrum for the Anderson model on a product of a tree with a finite graph.*

We will discuss some results and open problems about the absolutely continuous spectrum for the Anderson model on the tree analogue of a strip. (Received January 25, 2011)

1069-81-347 **Yang Kang**, **Eman Hamza** and **Jeffrey Schenker*** (jeffrey@math.msu.edu). *Diffusion of wave packets in a fluctuating random potential.*

I will discuss the problem of proving diffusion of waves in a random environment in the context of the lattice Schroedinger equation. A major difficulty that arises is recurrence – return of portions of the wave packet to regions previously visited. I will show that, if recurrence is eliminated by making the environment evolve randomly in time, then diffusion results in an elementary way. (Received January 25, 2011)

82 ► Statistical mechanics, structure of matter

1069-82-133 **Gunter Stolz*** (stolz@uab.edu) and **Robert Sims** (rsimsdrb@gmail.com). *Zero-velocity Lieb-Robinson bounds in the disordered xy-spin chain.* Preliminary report.

The well understood phenomenon of Anderson localization says (in its dynamical formulation) that adding random fluctuations to the potential of a Schrodinger operator will lead to the absence of wave transport for the

solution of the time-dependent Schrodinger equation. Several years ago it was argued by Burrell and Osborne that a corresponding phenomenon should hold in quantum spin systems. As an example they used the xy-spin chain to show on the physical level of rigor that the introduction of disorder will lead to zero-velocity Lieb-Robinson bounds. We will show how recent results on Anderson localization can be used to make this result rigorous and, in fact, to improve on the conclusions reached by Burrell and Osborne. (Received January 20, 2011)

1069-82-308 **Michael Szafron** and **Christine Soteros*** (soteros@math.usask.ca), soteros@math.usask.ca. *Knot reduction for a lattice polygon model of local strand passage.*

From DNA experiments, it is known that enzymes (known as topoisomerases) can reduce the fraction of knots in DNA over that found in randomly cyclized DNA; the amount that the fraction of knots is reduced is one measure of "knot reduction". These topoisomerases act locally in the DNA by transiently breaking one strand of DNA to allow another strand to pass through (strand passage). We use a self-avoiding polygon model on the simple cubic lattice to model this strand passage action. Our recent Monte Carlo results on how knot reduction depends on the local juxtaposition structure at the strand passage site for this model will be presented. We find a correlation between knot reduction and the angle of the crossing at the strand passage site; this angle has been shown experimentally by Neuman et al (2009) to be important in explaining topoisomerase action on DNA. The angle calculated depends on the sign of the crossing at the strand passage site and we find that knot reduction also depends on this crossing sign. (Received January 25, 2011)

1069-82-355 **Tian Ma** and **Shouhong Wang*** (showang@indiana.edu), Bloomington, IN 47401. *Dynamic Transition Theory and its Application to Gas-Liquid Phase Transitions.*

Gas-liquid transition is one of the most basic problems in equilibrium phase transitions. In the pressure-temperature phase diagram, the gas-liquid coexistence curve terminates at a critical point C, also called the Andrews critical point. It is, however, still an open question why the Andrews critical point exists and what is the order of transition going beyond this critical point. To answer this basic question, using the Landau's mean field theory and the Le Chatelier principle, a dynamic model for the gas-liquid phase transitions is established, and the model is consistent with the van der Waals equation in steady state level. With this dynamic model, we are able to derive a theory on the Andrews critical point C: 1) the critical point is a switching point where the phase transition changes from the first order with latent heat to the third order, and 2) the liquid-gas phase transition going beyond Andrews point is of the third order. This clearly explains why it is hard to observe the liquid-gas phase transition near the critical point. In addition, the study suggests an asymmetry principle of fluctuations, which we also discover in phase transitions for ferromagnetic systems. (Received January 25, 2011)

1069-82-358 **Andreas Hanke*** (hanke@phys.utb.edu), University of Texas at Brownsville, Department of Physics and Astronomy, 80 Fort Brown, Brownsville, TX 78520, **Stefan M Giovan** (smg021000@utdallas.edu), University of Texas at Dallas, Department of Molecular and Cell Biology, 800 West Campbell Road, Richardson, TX 75083, and **Stephen D Levene** (sdlevene@utdallas.edu), University of Texas at Dallas, Department of Molecular and Cell Biology, 800 West Campbell Road, Richardson, TX 75083. *Partition Functions and Entropy Estimates for Multiscale Models of DNA.*

Multiscale modeling has become a major focus in computational chemistry and biology in order to simulate systems of ever-increasing complexity. To properly treat such systems on multiple length scales, it is necessary to rigorously treat the momenta and coordinates of the individual entities that make up the system of interest. We use principles of polymer physics to model DNA on two different length scales: individual DNA base pairs and rigid cylinders composed of many base pairs. Our results yield rigorous expressions for the partition functions of these systems, from which equilibrium thermodynamic properties can be obtained. Potential applications of our modeling to obtain entropy estimates from quasi-harmonic analysis are addressed. (Received January 25, 2011)

90 ► Operations research, mathematical programming

1069-90-10 **Qinghong Zhang*** (qzhang@nmu.edu), 1401 Presque Isle Ave, Marquette, MI 49855. *Embedding methods for semidefinite programming.*

Embedding methods for semidefinite programming problems using the Extended Lagrange-Slater Dual (ELSD) formulated by Ramana, Tunçel, and Wolkowicz in 1997 have recently been developed. Since ELSD usually

involves a large number of variables, numerically solving this newly developed embedding problem is challenging. To see how the existing software work for this problem, we have performed some numerical experiments. We will report our computational experience in solving this embedding problem using the packages such as SeDuMi, SDPT3, and SDPA. (Received November 01, 2010)

91 ► Game theory, economics, social and behavioral sciences

1069-91-318 **Roger Lee*** (RL@math.uchicago.edu). *Asymptotics of Implied Volatility in Extreme Regimes.*

In a unified model-free framework that includes large-expiry, small-expiry, and extreme-strike regimes, we find asymptotic implied volatility and implied variance formulas in terms of L, with rigorous error estimates of the type $O(1/L^J)$ as $L \to \infty$, for any given $J > 0$, where L denotes the absolute log of an option price that approaches zero. (Received January 25, 2011)

92 ► Biology and other natural sciences

1069-92-139 **Sarah A Harris*** (s.a.harris@leeds.ac.uk), School of Physics and Astronomy, University of Leeds, Leeds, LS2 9JT, England. *Computer Simulations of DNA Supercoiling at the Atomic Level.*

Small DNA circles offer a controllable model system for the systematic exploration of the dependence of DNA structure on supercoiling. We use computer simulation to explore the supercoiling-dependent conformation of small DNA circles and how this is affected by supercoiling, salt concentration, DNA sequence and the size of the circles [1, 2]. The calculations use atomistic molecular dynamics simulation, and employ both implicit and explicit solvent models. We have performed simulations that enable us to systematically decompose the thermodynamic forces that drive the writhing of DNA at high salt concentrations, and the opening of plectonemic structures at low salt concentrations. These simulations provide a biophysical explanation of the thermodynamics of DNA writhing in response to supercoiling.

[1] Harris, S. A., Laughton, C. A. & Liverpool, T. B. (2008). Mapping the phase diagram of the writhe of DNA nanocircles using atomistic molecular dynamics simulations. Nucleic Acids Res 36, 21-9. [2] Mitchell J. S., Laughton C. A. & Harris S. A. (2011) Atomistic simulations reveal bubbles, kinks and wrinkles in supercoiled DNA. Nucleic Acids Res. Doi: 10.1093/nar/gkq1312. (Received January 20, 2011)

1069-92-168 **Jonathan Simon*** (jonathan-simon@uiowa.edu), **De Witt Sumners** (sumners@math.fsu.edu), **Stu Whittington** (swhittin@chem.utoronto.ca) and **Lynn Zechiedrich** (elz@bcm.edu). *Panel on open problems.* Preliminary report.

Panel will lead wide-ranging discussion of open problems in several areas: DNA geometry and energetics; topological models of DNA; protein knotting and tangling; chromatin geometry and topology; modeling general polymers. (Received January 22, 2011)

1069-92-171 **Chu-chun Hunag**, Molecular Genetics & Microbiology, 1 University Station A5000, UT Austin, Austin, TX 78712, **Santanu K Ghosh**, Department of Biosciences and Bioengineering, Indian Institute of Technology, Powai, Mumbai, 400076, India, and **Makkuni Jayaram*** (jayaram@icmb.utexas.edu), Molecular Genetics & Microbiology, 1 University Station A5000, UT Austin, Austin, TX 78712. *The DNA and protein topology of chromosome segregation.*

Equal segregation of chromosomes is vital for life. We will discuss two topological aspects, one relevant to protein and the other to DNA, which dictate the fidelity of chromosome segregation. Our experimental system is a small plasmid in yeast, which exhibits nearly the same stability as the chromosomes of its host. The DNA locus on chromosomes that directs the opposite movement of sister chromosomes is called 'centroemre' (CEN). The identity of CEN appears to be specified by DNA topology. That is, CEN DNA is wrapped around a specialized nucleosome in a contrary right handed fashion. We will present evidence to show that the plasmid locus STB, responsible for equal plasmid segregation, is also wrapped around such a nucleosome with a right handed writhe. Thus, a unique DNA topology signals the identity of the partitioning loci of chromosomes and plasmid. Cohesin, a four subunit protein assembly, bridges sister chromosomes to ensure their biorientation on the spindle, thus one-to-one segregation. Cohesin assembled at CEN appears to trap two sister CEN copies by entrapping them

topologically within a large non-covalently closed protein ring. Our experimental results reveal that two sister copies of STB are also paired by cohesin through a topological embrace mechanism. (Received January 22, 2011)

1069-92-191 **De Witt Sumners*** (sumners@math.fsu.edu), Florida State University, Department of Mathematics, Tallahassee, FL 32306. *Topological Epigenetics: DNA Entanglement and Gene Expression.*

This talk will discuss effects of DNA entanglement on gene expression, and the utility of topological methods in research on chromatin structure and cancer biology. (Received January 23, 2011)

1069-92-212 **J. Burns**, **E. Dolzhenko** and **N. Jonoska*** (jonoska@math.usf.edu), Department of Mathematics, University of South Florida, 4202 E. Fowler Av. PHY 114, Tampa, FL 33620, and **T. Muche** and **M. Saito**. *DNA rearrangements through spacial graphs.* Preliminary report.

Motivated by a recent model for RNA-guided DNA rearrangements in certain species of ciliates we investigate vertex-smoothing on graphs that consist of 4-valent rigid vertices, called assembly graphs. An assembly graph can be seen as a representation of the DNA during certain recombination processes in which 4-valent vertices correspond to the alignment of the recombination sites. A single gene is modeled by a polygonal path in an assembly graph. A polygonal path makes a "right-angle" turn at every vertex, defining a particular smoothing of a 4-valent vertex and therefore modeling the recombination process. We investigate properties of these graphs, number of possible polygonal paths, smoothing of their vertices, and their relationship to circle graphs. (Received January 24, 2011)

1069-92-241 **James A Vance*** (jav6e@uvawise.edu), One College Avenue, Wise, VA 24266, and **Derek Fields**. *Sensitivity Analysis of the Three-Species Linear Response Omnivory Model.*

We investigate a three-species omnivory model with linear functional and numerical responses consisting of a coupled system of nonlinear differential equations. As estimates from natural systems, the model parameters are subject to natural intrinsic variability and measurement error. We use sensitivity analysis to determine how infinitesimal changes in parameters, corresponding to variability and error, affect the population densities. Our analysis allows us to determine which parameters must be estimated with as much accuracy as possible to ensure reasonable population density estimates. We apply theorems on continuous dependence and differentiability with respect to parameters to our model to derive sensitivity equations. Solving the sensitivity equations using an adaptive step numerical integration method and the use of a weighted norm allow for a comparison of sensitivities. We show that small changes in the predator mortality rate cause the greatest change in the model solution. Thus, biologists should take extra care in the field to accurately collect data to determine the predator mortality rate. Also, we determine the least sensitive parameter to be the biological carrying capacity of the basal resource. (Received January 24, 2011)

1069-92-286 **Joanna Ida Sulkowska*** (jsulkow@physics.ucsd.edu), Center for Theoretical Biological Physics, University of California San Diego, 9500 Gilman Dr., La Jolla, CA 92093, **Piotr Sulkowski** (psulkows@theory.caltech.edu), California Institute of Technology, 1200 E. California Blvd., Pasadena, CA 91125, **Piotr Szymczak** (piotrek@fuw.edu.pl), University of Warsaw, Hoza 69, 00-681 Warsaw, Poland, **Marek Cieplak** (mc@ifpan.edu.pl), Polish Academy of Sciences, Al. Lotnikow 32/46, 02-668 Warsaw, Poland, and **Jose Nelson Onuchic** (jonuchic@physics.ucsd.edu), Center for Theoretical Biological Physics, University of California San Diego, 9500 Gilman Dr., La Jolla, CA 92093. *Untying knots in proteins.*

A shoelace can be readily united by pulling by its ends rather than by its loop. Attempting to untie a native knot or slipknot my results in an outcome which is much less unique since its intrinsic structure has non-uniform mechanical properties. We used structure based model to show that: 1. Stretching slipknots reveals a surprising growth of their unfolding times when the stretching force crosses an intermediate threshold. This behavior arises as a consequence of intermediate states in which the slipknot is jammed, and which correspond to so-called catch bonds. 2. Pulling knotted proteins by specific amino acids may cause retraction of a terminal segment of the backbone from the knotting loop and untangle the knot, as opposite to pulling by termini. At still other amino acids, the outcome of pulling can go either way. We study the dependence of the untying probability on the way the protein is grasped, the pulling speed, and the temperature. Elucidation of the mechanisms underlying this dependence is critical for a successful experimental realization of protein knot untying. (Received January 25, 2011)

1069-92-317 **Massa J Shoura*** (dnabubble@gmail.com), Department of Molecular and Cell Biology, University of Texas at Dallas, 800 West Campbell Road, Richardson, TX 75080, and **Anusha Bharadwaj**, **Matthew R Kesinger**, **Farah H Bardai**, **Alexandre A Vetcher** and **Stephen D Levene**. *New Insights into the Mechanism of Tyrosine Recombinases from DNA Loop-closure Kinetics.*

The Cre recombination system has become an important tool for genetic manipulation of higher organisms and a paradigm for site-specific DNA-recombination mechanisms employed by the lambda-int superfamily of recombinases. A hallmark of the int superfamily is that recombination takes place via a four-stranded, Holliday-junction DNA intermediate. It is difficult, however, to reconcile the square-planar exchange mechanism attributed to co-crystal structures with evidence for a chiral recombination intermediate observed using circular DNA substrates. We report a novel approach for characterizing the structures, in solution, of a synaptic intermediate in Cre recombination based on an analysis of the kinetics of intra- and intermolecular recombination. Because the mechanism of Cre recombinase does not conform to a simple kinetic scheme, we employ numerical methods to extract rate constants for fundamental steps in the recombination pathway. The rate constants obtained for the synapsis steps are then used to determine the probability of DNA-loop formation in an intramolecular recombination reaction. Our analysis suggests that the longest-lived intermediate has a structure distinct from those observed in x-ray co-crystal structures. (Received January 25, 2011)

1069-92-324 **Anthony G Montemayor*** (anthony.montemayor477@topper.wku.edu), 1906 College Heights Blvd., Bowling Green, KY 42101, and **Claus Ernst** (claus.ernst@wku.edu), 1906 College Heights Blvd., Bowling Green, KY 42101. *The nullification number for knots and links.*

Nullification is a local crossing change operation that mimics types of DNA strand recombination. This talk will present a geometric/topological measure of knots and links called the *nullification number*. We will discuss the relation between this number and other knot invariants allowing tabulation of nullification numbers for knots with small crossing number. (Received January 25, 2011)

1069-92-344 **Sarah Harris*** (s.a.harris@leeds.ac.uk). *Tutorial on DNA Geometry and Energetics.*

This tutorial will be aimed at students, post-docs, and faculty from a variety of disciplines including mathematics and biological sciences with the aim of increasing interdisciplinary communication and collaboration. This presentation will help prepare conference participants for related research talks. (Received January 25, 2011)

1069-92-356 **Mariel Vazquez*** (mariel@mah.sfsu.edu), Mathematics Department, 1600 Holloway Avenue, San Francisco, CA 94132. *DNA unlinking by Xer recombination.* Preliminary report.

Replication of circular chromosomes requires unwinding of the DNA and results in the formation of DNA links. In Escherichia coli, error-free unlinking is required to ensure proper segregation at cell division. The Xer site-specific recombination system mediates sister chromosome unlinking in TopoIV deficient cells. We here study the topological mechanism of DNA unlinking by Xer recombination system. We use the tangle method to find possible topological pathways of DNA unknotting and unlinking by site-specific recombination on small substrates. When assuming that the enzymes systematically reduce the topological complexity of the substrates, we provide rigorous proof that there is only one possible unlinking pathway. For example the XerCD-FtsK system unlinks 6-crossing catenanes in a stepwise manner, converting the 6-cat into a 5-knot, into a 4-cat, into a 3-knot etc. . . until reaching the unlinked state. This is joint work with Kai Ishihara, Koya Shimokawa, Ian Grainge, David J.Sherratt. (Received January 25, 2011)

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ABSTRACTS

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