

ABSTRACTS

of Papers Presented to the
American Mathematical Society

Volume 34, Number 3, Issue 173

Summer 2013

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ISSN 0192-5857

Pages 781–920

AMS

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* Indicates who will present the paper at the meeting.

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Abstracts of Papers Presented to the American Mathematical Society (ISSN 0192-5857) is published four times a year by the American Mathematical Society at 201 Charles Street, Providence, RI 02904-2294. The subscription price for Volume 34 (2013) is US\$161.00 list, US\$128.80 institutional member, US\$96.60 individual member. Subscription renewals are subject to late fees. See www.ams.org/customers/macsfac.html#journal for more information. Periodicals postage paid at Providence, RI. Add for postage: Surface delivery to destinations outside the U.S.—US\$11. If ordering the paper version, add US\$5 for delivery within the United States; US\$11 for delivery outside the United States. POSTMASTER: Send address change notices to *Abstracts of Papers Presented to the American Mathematical Society*, 201 Charles Street, Providence, RI 02904-2294 USA.

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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
1091	June 27–30, 2013	Alba Iulia, Romania	TBA	None
1092	October 5–6, 2013	Louisville, KY	August 13	Vol 34, No. 3
1093	October 12–13, 2013	Philadelphia, PA	August 20	Vol 34, No. 3
1094	October 18–20, 2013	St. Louis, MO	August 27	Vol 34, No. 4
1095	November 2–3, 2013	Riverside, CA	September 10	Vol 34, No. 4
1096	January 15–18, 2014	Baltimore, MD	TBA	Vol 35, No. 1
1097	March 21–23, 2014	Knoxville, TN	TBA	TBA
1098	March 29–30, 2014	Baltimore, MD	TBA	TBA
1099	April 5–6, 2014	Albuquerque, NM	February 11	TBA
2000	April 11–13, 2014	Lubbock, TX	February 10	TBA

OXFORD, MS, March 1–3, 2013

Abstracts of the 1087th Meeting.

00 ► *General*

1087-00-3 **Washington Mio*** (mio@math.fsu.edu), Department of Mathematics, Florida State University, Tallahassee, FL 32306-4510. *Taming Shapes and Understanding Their Variation.*

Identification of shape and quantification of morphological variation are problems that arise in a variety of contexts. Problems such as understanding development, evolution and inheritance of phenotypic traits, quantifying normal and pathological changes in the anatomy of organs and tissues, recognizing objects in images, all involve shape analysis. Shapes of interest also may be quite irregular, as exemplified by those often found in gene expression domains or in noisy scans of objects. Thus, a companion problem is that of regularizing shapes to make them more manageable and amenable to analysis.

In this talk, we will discuss several developments in interpolation techniques for taming shapes, shape spaces and metrics that provide a framework for modeling shape variation, and methods to select shape metrics best suited to a particular problem. We also will illustrate the methods with applications to biology and medical imaging. (Received December 04, 2012)

03 ► *Mathematical logic and foundations*

1087-03-7 **Slawomir Solecki*** (ssolecki@math.uiuc.edu), Department of Mathematics, 1409 W. Green Street, University of Illinois, Urbana, IL 61801. *An abstract approach to Ramsey theory with applications.*

I will present an abstract approach to finite Ramsey theory, which reveals the formal algebraic structure underlying results of that theory. I will formulate within this approach an abstract pigeonhole principle and an abstract Ramsey condition, and state a theorem that the pigeonhole principle implies the Ramsey condition. I will indicate how Ramsey results become special instances of this general theorem (among them the classical Ramsey theorem, the Graham–Rothschild theorem, Spencer’s Ramsey theorem for spaces, Milliken’s theorem for finite trees, a new self-dual Ramsey theorem, and a new common generalization of Deuber’s and Jasinski’s Ramsey theorems for finite trees). (Received September 24, 2012)

1087-03-22 **Michael P Cohen*** (michaelcohen@my.unt.edu), 1600 W. Oak St. Apt. 3, Denton, TX 76201. *The descriptive complexity of series rearrangements.*

We consider the descriptive complexity of some subsets of the infinite permutation group S_∞ which arise naturally from the classical series rearrangement theorems of Riemann, Levy, and Steinitz. In particular, given some fixed conditionally convergent series of vectors in Euclidean space \mathbb{R}^d , we study the set of permutations which make the series diverge, as well as the set of permutations which make the series diverge properly. We show that both collections are Σ_3^0 -complete in S_∞ , regardless of the particular choice of series.

The proof involves a blend of the descriptive set theoretic notion of continuous reducibility, with the purely geometric techniques employed by Steinitz himself in his original proof of the Levy-Steinitz Theorem. In particular, we appeal to the existence of a perhaps not sufficiently famous geometric constant, now referred to as the Steinitz constant. (Received November 07, 2012)

1087-03-37 **Miodrag Sokic*** (msokic@caltech.edu), 1200 E. California Bld., Pasadena, CA 91101. *Directed graphs and Boron trees.* Preliminary report.

We consider the class of finite Boron trees with arbitrary linear orderings and the class of dense local orders with arbitrary linear orderings. We calculate Ramsey degrees of objects from these classes and give topological interpretation of our results. (Received November 16, 2012)

1087-03-60 **Gun-Won Lee*** (lgnwn7@gmail.com), Rm 101, 41-13 Yulgokro-19-gil, Jongnoku, Seoul, 110-500, South Korea. *Dynamics in illocutions.* Preliminary report.

The dynamics in the illocutions of Searle type can be measured as the relations between the illocutionary commitments as they worked out. This system of measurement is similar to that of psychological states in a sense that we cannot judge the forces in the utterance as it appeared. Hence it cannot be done within the linguistic observations only. But it should be measured in terms of the effect of illocutionary acts enough to say that it is more than linguistic work as the study of order in Aristotle. First, the criteria to judge the effects of the illocutionary act cannot be limited in the linguistic works only but they should consider all in our life world. Second, as the historical facts, the effects of the illocutionary act can be measured. Language has been accepted to try to use the finite means for the infinite goals. Therefore the illocutionary effects appeared already only should be the observed data as the eligible in this dynamics in the illocutions measurement, I think. (Received November 25, 2012)

1087-03-70 **Su Gao*** (sgao@unt.edu), Department of Mathematics, University of North Texas, 1155 Union Circle #311430, Denton, TX 76203. *Borel Complete Sections on Bernoulli Shifts, Part II.*

I will discuss the proof of a non-existence result for certain sequences of Borel complete sections on Bernoulli shifts. The only known proof uses a forcing argument. For this we define a forcing notion for constructing 2-colorings in a generic extension. This is joint work with S. Jackson and B. Seward, and this talk is a continuation of Seward's talk in the same session. (Received November 27, 2012)

1087-03-73 **Alexander S Kechris*** (kechris@caltech.edu), Department of Mathematics, 253-37, California Institute of Technology, Pasadena, CA 91125. *Topological dynamics and ergodic theory of automorphism groups.*

In this talk I will discuss some recent developments concerning the study of the dynamics of automorphism groups of countable structures and its connections with finite Ramsey theory. (Received November 27, 2012)

1087-03-75 **Grigor Sargsyan*** (grigor@math.rutgers.edu), 100 Hiram Square Apt 426, New Brunswick, NJ 08901. *On the strength of the failure of UBH.*

We will illustrate how the core model induction can be used to mine strength out of the failure of the unique branch hypothesis. This is a joint work with Nam Trang. (Received November 27, 2012)

1087-03-84 **Simon Thomas and Jay Williams*** (jaywill@caltech.edu), Mathematics 253-37, Caltech, Pasadena, CA 91125. *The bi-embeddability relation for finitely generated groups.*

Using a construction of B.H. Neumann, we show that there is no Borel way to select an isomorphism class within each bi-embeddability class in the space of finitely generated groups. (Received November 28, 2012)

1087-03-111 **Aleksandra Kwiatkowska*** (akwiatk@ucla.edu). *Conjugacy classes of an automorphism group related to the pseudo-arc.*

The pseudo-arc is an important example of a hereditary indecomposable compact and connected space. The pseudo-arc can be realized as a natural quotient of a certain projective Fraisse limit L , as proved by Irwin and Solecki. We show that $Aut(L)$, that is, the group of all automorphisms of L , has a comeager conjugacy class.

This generalizes a very recent result due to Oppenheim, who showed that $Aut(L)$ has a dense conjugacy class. (Received November 30, 2012)

1087-03-127 **Natasha Dobrinen*** (natasha.dobrinen@du.edu), Department of Mathematics, 2360 S Gaylord St, Denver, CO 80208. *Non-p-points near the bottom of the Tukey hierarchy.*

We present new classification theorems regarding the Rudin-Keisler and Tukey types of ultrafilters which are very close to selective ultrafilters, yet are not even p-points. (Received December 01, 2012)

1087-03-133 **Su Gao, Steve Jackson** and **Brandon Seward*** (bseward@umich.edu), 2074 East Hall, Department of Mathematics, 530 Church Street, Ann Arbor, MI 48109. *Borel Complete Sections on Bernoulli Shifts, Part I.*

I will discuss the non-existence of certain sequences of Borel complete sections on Bernoulli shifts. I will discuss some applications of this result and go through the proof in the case of clopen complete sections. (Received December 02, 2012)

1087-03-145 **Sean D Cox***, Department of Mathematics and Applied Mathema, Virginia Commonwealth University, 1015 Floyd Avenue, Richmond, VA 23284. *Generalized Laver Diamond and Chang's Conjecture.*

Viale [1] considered a natural generalization of a Laver function which makes sense at successor cardinals, and proved that the Proper Forcing Axiom implies there is such a function from $\omega_2 \rightarrow H_{\omega_2}$. I will discuss the relative abundance of Laver functions on successor cardinals, and their relation to Chang's Conjecture.

References

[1] Viale, Matteo, Guessing models and generalized Laver diamond, *Ann. Pure Appl. Logic* **163**, (2012), no. 11, 1660–1678, MR2959666, DOI: 10.1016/j.apal.2011.12.015, <http://dx.doi.org/10.1016/j.apal.2011.12.015> (Received December 02, 2012)

1087-03-152 **Paul B. Larson*** (larsonpb@uohio.edu), Department of Mathematics, Miami University, Oxford, OH 45056. *A choice function on countable sets, from determinacy.*

We prove that $AD_{\mathbb{R}}$ implies the existence of a Choice function which selects a finite subset of countable set X , given a tall ideal I on ω containing Fin and a function $C: I \setminus \text{Fin} \rightarrow X$. This gives an alternate proof of the fact (previously established by Di Prisco - Todorcevic) that there is no selector for the E_0 degrees in the $\mathcal{P}(\omega)/\text{Fin}$ -extension of a model of $AD_{\mathbb{R}}$. (Received December 03, 2012)

1087-03-153 **Andrew Marks*** (marks@caltech.edu), California Institute of Technology, Department of Mathematics MC 253-37, Pasadena, CA 91106. *Determinacy and structure theorems for countable Borel equivalence relations.*

We use Borel determinacy to prove some structure theorems for the universal treeable countable Borel equivalence relation $E_{\infty T}$. We show that $E_{\infty T}$ is not a smooth disjoint union of non-universal treeable countable Borel equivalence relations, that $E_{\infty T}$ achieves its universality on a nullset with respect to every Borel probability measure, and that universality for Borel reductions and universality for Borel embeddings coincide for the class of treeable equivalence relations. Our results follow from the existence of a countably complete ultrafilter on the invariant Borel sets of $E_{\infty T}$ for which every element of the ultrafilter is universal. Our proofs also generalize to some other universal \mathcal{K} -structurable equivalence relations. (Received December 03, 2012)

1087-03-169 **Clinton T. Conley*** (clintonc@math.cornell.edu), **Alexander S. Kechris** and **Benjamin D. Miller**. *Stationary probability measures and σ -compact realizations for aperiodic Borel actions of countable groups.*

We discuss the generic inexistence of stationary Borel probability measures for aperiodic Borel actions of countable groups on Polish spaces. Using this, we show that every aperiodic continuous action of a countable group on a compact Polish space has an invariant Borel set on which it has no σ -compact realization. (Received December 03, 2012)

1087-03-179 **Su Gao** and **Aaron Hill*** (aaron.hill@unt.edu). *The Polish space of concrete rank-1 systems.*

In this talk we will discuss concrete rank-1 systems. Each such system is a triple, (X, μ, σ) , where X is a Cantor space, μ is an atomless Borel measure on X , and σ is a measure-preserving homeomorphism of (X, μ) .

We will discuss two natural topologies on \mathcal{R} , the collection of all concrete rank-1 systems. We'll show that these two topologies are Polish and that they generate the same σ -algebra on \mathcal{R} . Finally, we'll briefly discuss the topological and measure-theoretic isomorphism problems for concrete rank-1 systems. (Received December 03, 2012)

1087-03-192 **John Krueger*** (jkrueger@unt.edu), Department of Mathematics, University of North Texas, 1155 Union Circle #311430, Denton, TX 76203. *Forcing with Finite Conditions.*

We describe a method for forcing with finite conditions a generic object on the second uncountable cardinal, using adequate sets of countable elementary substructures as side conditions. (Received December 03, 2012)

1087-03-199 **Scott Schneider*** (sschnei@umich.edu) and **Brandon Seward** (bseward@umich.edu).

Countable nilpotent group actions and hyperfinite equivalence relations. Preliminary report.

An equivalence relation E on the standard Borel space X is hyperfinite if E is the increasing union of a sequence of Borel equivalence relations with finite classes. Recently Gao and Jackson used Borel marker sets to prove that the orbit equivalence relation arising from a Borel action of a countable abelian group is hyperfinite. We extend their methods to prove the analogous result for free Borel actions of countable nilpotent groups. (Received December 04, 2012)

1087-03-202 **Robin D Tucker-Drob*** (rtuckerd@caltech.edu), Caltech Mathematics Department, 1200 E. California Blvd. MC 253-37, Pasadena, CA 91125. *Freeness properties of measure preserving actions of countable groups.*

In this talk I will discuss the relationship between non-free measure preserving actions, invariant random subgroups, and weak equivalence. I will describe how invariant random subgroups may be used to classify the measure preserving actions of an amenable group up to weak equivalence. For non-amenable groups, where the situation is much different, I will indicate connections between the above notions and the theory of cost. (Received December 04, 2012)

05 ► Combinatorics

1087-05-1 **Patricia Hersh*** (plhersh@ncsu.edu), Box 8205, North Carolina State University, Raleigh, NC 27695-8205. *An interplay of combinatorics with topology.*

Decades ago, Rota initiated a very fruitful interaction of combinatorics with topology, drawing attention to the fact that each coefficient in any inclusion-exclusion counting formula is exactly the reduced Euler characteristic of a simplicial complex called the order complex of a partially ordered set (poset). This area of "poset topology" has seen powerful applications to finite group theory, commutative algebra, and complexity theory, just to name a few of the impacted areas. We will discuss a method for getting at the topology of these order complexes through discrete Morse theory.

Then we turn to a second sort of interplay of combinatorics with topology. Given a stratification of a topological space, one associates a partially ordered set called its face poset that keeps track of which cells are in the closure of which others. We will discuss recent efforts to understand the homeomorphism type of a stratified space using this combinatorial data in conjunction with relatively simple codimension one topological data. We conclude with an application to stratified spaces arising from combinatorial representation theory which have the Bruhat intervals as their closure posets, giving an affirmative answer to a conjecture of Fomin and Shapiro. (Received December 02, 2012)

1087-05-8 **Ralph J Faudree*** (rfaudree@memphis.edu), Department of Mathematical Sciences, University of Memphis, Memphis, TN 38152. *Minimum Degree and Disjoint Cycles in Generalized Claw-free Graphs.*

For $s \geq 3$ a graph is $K_{1,s}$ -free, if it does not contain an induced subgraph isomorphic to $K_{1,s}$. For $s = 3$, such graphs are called claw-free graphs. Results on disjoint cycles in claw-free graphs satisfying certain minimum degree conditions will be discussed, such as if G is claw-free of sufficiently large order $n = 3k$ with $\delta(G) \geq n/2$, then G contains k disjoint triangles. Also, the extension of results on disjoint cycles in claw-free graphs satisfying certain minimum degree conditions to $K_{1,s}$ -free graphs for $s > 3$ will be presented. These results will be used to prove the existence of minimum degree conditions that imply the existence of powers Hamiltonian cycle in generalized claw-free graphs. (Received September 24, 2012)

1087-05-12 **Elizabeth Niese*** (niese@marshall.edu), Huntington, WV 25755. *Recursions for combinatorial Macdonald polynomials.*

The Hilbert series of the Garsia-Haiman module can be described combinatorially as the generating function of standard fillings of the Ferrers diagram of the indexing integer partition. One of the advantages of the combinatorial definition is that it is clear from this definition that the series is a polynomial with nonnegative integer coefficients. However, there are a large number of fillings needed to generate the polynomial, so it is desirable to find recursions to reduce the number of fillings under consideration. In this talk we present a

recursion that is valid for partitions with two or three columns of equal height and a general strategy to extend the recursion to larger rectangles. (Received November 27, 2012)

1087-05-17 **Joseph P Kung*** (kung@unt.edu), Department of Mathematics, 1155 Union Circle Box 311430, Denton, TX 76203-5017. *The chromatic and Tutte polynomial as a resultant force.*

A flow over a matrix G with columns indexed by E is a row vector in the row space of G , considered as a function on E . We will work with matrices over a finite field of order q . A parcel is a subset of pairs (f, g) of functions defined on E such that $f - g$ is a flow, satisfying a congruence condition (that an algebraic or combinatorial function of f and g satisfies some congruence condition). We will discuss several theorems of the form: a linear combination of sizes of parcels, with coefficients roots of unity, equals a simple multiple of an evaluation of the Tutte polynomial of the matroid on E defined by linear dependence of the columns of G at a point (u, v) , where $(u - 1)(v - 1) = q$. One of the theorems will give an interpretation of the evaluation of the chromatic polynomial of a graph at a prime power q as a “resultant force.” (Received November 01, 2012)

1087-05-19 **Wayne Goddard** (goddard@clemson.edu), **Douglas Rall** (doug.rall@furman.edu) and **Kirsti Wash*** (kirstiw@clemson.edu). *Identifying Codes in Graph Products.*

An identifying code in a graph is a set having the property that the closed neighborhood of each vertex in the graph has a nonempty, distinct intersection with the set. The minimum cardinality of an identifying code in a graph G is denoted $\gamma^{ID}(G)$. In this talk, we focus on computing $\gamma^{ID}(G)$ where G is the cartesian or direct product with at least one factor being a clique. We also discuss the natural relationship between identifying codes, total domination and independent domination. This is joint work with Wayne Goddard of Clemson University and Douglas Rall of Furman University. (Received November 04, 2012)

1087-05-29 **Drew Armstrong** and **Victor Reiner*** (reiner@math.umn.edu), School of Mathematics, University of Minnesota, 206 Church St. SE, Minneapolis, MN 55455, and **Brendon Rhoades**. *Parking spaces.*

Classical parking spaces are the fascinating permutation action of the symmetric group on parking functions. They are related to nonnesting partitions and the theory of diagonal harmonics, and generalize to W -parking spaces for finite Weyl groups W .

This talk describes a different W -parking space, related to noncrossing partitions. It conjecturally carries the same W -permutation representation, but also an extra cyclic action, and generalizes to finite real reflection groups. Whenever this conjecture holds, it has interesting consequences for W -Catalan combinatorics. (Received November 10, 2012)

1087-05-32 **Kwang Ju Choi***, Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, and **Bogdan Oporowski**, Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *A Characterization of almost all minimal not nearly planar graphs.* Preliminary report.

In this work, we define *nearly planar* graphs G that are planar graphs or have an edge e such that $G \setminus e$ is planar. The class of nearly planar graphs are closed not under minors but under topological minors. Since we can make a trivial infinite series of planar graphs using an operation, namely parallel subdivision, we define a relation \lesssim between two graphs which is an extension of the topological minor relation. We define \mathcal{M} to be the minimal excluded class of nearly planar graphs under \lesssim . We prove that all members of \mathcal{M} , except finitely many, contain a Möbius ladder and are made by three blocks. (Received November 14, 2012)

1087-05-36 **João P. Costalonga*** (joaocostalonga@yahoo.com.br), Av. Colombo, 5790 - Campus UEM, Depto de Matemática, bl.F67 sl.221, Maringá, Paraná 87020-900, Brazil. *Non-separating cocircuits and graphicness in matroids.* Preliminary report.

The concept of non-separating cocircuit in a binary matroid is the closer concept for matroids to the one of vertices in graphs. A cocircuit C^* in a connected matroid M is said to be *non-separating* if $M \setminus C^*$ is a connected matroid. For a 3-connected graph G , the unique non-separating cocircuits of $M(G)$ are the stars of the vertices of G .

Let M be a 3-connected binary matroid with more than four elements. Bixby and Cunningham proved that M is graphic if and only if, in M , each element belongs to at most two non-separating cocircuits. Lemos proved that M is graphic if and only if each elements of M avoids at most $r^*(M) - 1$ non-separating cocircuits. In this work we study the set $Y(M)$ of the elements of M avoiding at least $r^*(M)$ non-separating cocircuits of M . We proved that if M is not graphic, $|E(M) - Y(M)| \leq 1$ when M is not regular or M has no $K_{3,3}'''$ -minor. We have a conjecture that if M is not graphic, then $r_M^*(E(M) - Y(M)) \leq 2$. We proved that this conjecture is valid in

general if and only if it holds on a determined finite class of matroids. The computational procedure to finish the proof of the conjecture is in course. (Received November 15, 2012)

1087-05-44 **Sarah K Mason***, masonsk@wfu.edu, and **Aaron Lauve**. *Between quasisymmetric and symmetric functions*. Preliminary report.

Hivert recently introduced a class of local actions of the symmetric group which are used to produce an infinite family of Hopf algebras interpolating between quasisymmetric and symmetric functions. We introduce a new collection of bases, one for each family, and describe their relationship to a conjecture of Bergeron and Reutenauer about the coinvariant rings of these families. (Received November 18, 2012)

1087-05-48 **Younjin Kim*** (younjin@kaist.ac.kr), Dept. of Mathematical Sciences, KAIST, Daejeon, South Korea, and **Sang June Lee** (sjlee242@gmail.com) and **Sang-il Oum** (sangil@kaist.edu). *Dynamic coloring of graphs having no K_5 minor*.

We prove that every simple connected graph with no K_5 minor admits a proper 4-coloring such that the neighborhood of each vertex v having more than one neighbor is not monochromatic, unless the graph is isomorphic to the cycle of length 5. This generalizes the result by S.-J. Kim, S. J. Lee, and W.-J. Park [Dynamic coloring and list dynamic coloring of planar graphs, submitted, 2012] on planar graphs. (Received November 22, 2012)

1087-05-51 **Sandra Kingan*** (skingan@brooklyn.cuny.edu), Department of Mathematics, Brooklyn College, 2900 Bedford Ave, Brooklyn, NY 11210, and **Manoel Lemos** (manoel@dmat.ufpe.br), Departamento de Matematica, Universidade Federal de Pernambuco, Recife, Pernambuco 50740-540, Brazil. *A decomposition theorem for binary matroids with no prism minor*.

The prism graph is the dual of the complete graph on five vertices with an edge deleted, $K_5 \setminus e$. In this paper we determine the class of binary matroids with no prism minor. The motivation for this problem is the 1963 result by Dirac where he identified the simple 3-connected graphs with no minor isomorphic to the prism graph. We prove that besides Dirac's infinite families of graphs and four infinite families of non-regular matroids determined by Oxley, there are only three possibilities for a matroid in this class: it is isomorphic to the dual of the generalized parallel connection of F_7 with itself across a triangle with an element of the triangle deleted; its rank is bounded by 5; or it admits a non-minimal exact 3-separation induced by the 3-separation in P_9 . Since the prism graph has rank 5, the class has to contain the binary projective geometries of rank 3 and 4, F_7 and $PG(3, 2)$, respectively. We show that there is just one rank 5 extremal matroid in the class. It has 17 elements and is an extension of R_{10} , the unique splitter for regular matroids. As a corollary, we obtain Dillon, Mayhew, and Royle's result identifying the binary internally 4-connected matroids with no prism minor [5]. (Received November 23, 2012)

1087-05-52 **Ping Li** (pingli@bjtu.edu.cn), Department of Mathematics, Beijing Jiaotong University, Beijing, 100044, Peoples Rep of China, **Hong-Jian Lai*** (hjlai@math.wvu.edu), Department of Mathematics, West Virginia University, Morgantown, WV 26506, and **Yanting Liang** (yt1814@hotmail.com), Department of Mathematics, University of Wisconsin-Fond du Lac, Fond du Lac, WI 54935. *Characterization of removable elements with respect to having k disjoint bases in a matroid*.

The well-known spanning tree packing theorem of Nash-Williams and Tutte characterizes graphs with k edge-disjoint spanning trees. Edmonds generalizes this theorem to matroids with k disjoint bases. This paper aims to determine, for a matroid M that has k disjoint bases, the set $E_k(M)$ of elements in M such that for any element e in $E_k(M)$, $M - e$ also has k disjoint bases. Using the matroid strength defined in [Fractional arboricity, strength and principal partitions in graphs and matroids, Discrete Appl. Math. 40 (1992) 285–302], we present a characterization of $E_k(M)$ in terms of the strength of M . Consequently, this yields a characterization of edge sets $E_k(G)$ in a graph G with at least k edge-disjoint spanning trees such that for any edge e in $E_k(G)$, $G - e$ also has k edge-disjoint spanning trees. (Received November 24, 2012)

1087-05-58 **Jinko Kanno*** (jkanno@latech.edu). *Genus and outerthickness of graphs*.

In designing a VLSI circuit, one must place macrocells on a printed circuit board while avoiding crossing-wires. The circuit board may be viewed as a surface, i.e. as a compact closed 2-dimensional manifold, and the circuit design can be viewed as a graph G where macrocells and wires of the circuit correspond to the vertices and edges of the graph. There are two methods to avoid a wire ("edge") crossing. One is adding a handle to a surface, and the other is decomposing G into planar subgraphs. In this talk, we consider decomposing G into a distinguished class of planar subgraphs, called outerplanar graphs. The minimum number of layers required for G is called either thickness or outerthickness, depending on whether each subgraph is planar or outerplanar,

respectively. We will present some new results on outerthickness and discuss the possibly of new relationships between non-orientable genus and outerthickness of graphs. (Received November 25, 2012)

1087-05-69 **Owen Hill** and **Gexin Yu***, Department of Mathematics, College of William and Mary, Williamsburg, VA 23188. *A relaxation of Steinberg's Conjecture*. Preliminary report.

A graph is (c_1, c_2, \dots, c_k) -colorable if the vertex set can be partitioned into k sets V_1, V_2, \dots, V_k , such that for every $i : 1 \leq i \leq k$ the subgraph $G[V_i]$ has maximum degree at most c_i . We show that every planar graph without 4- and 5-cycles is $(1, 1, 0)$ -colorable and $(3, 0, 0)$ -colorable. This is a relaxation of the Steinberg Conjecture that every planar graph without 4- and 5-cycles are properly 3-colorable (i.e., $(0, 0, 0)$ -colorable). (Received November 27, 2012)

1087-05-79 **Catherine Yan*** (cyan@math.tamu.edu), Department of Mathematics, 102 Milner Hall, MS 3368, College Station, TX 77843-3368, and **Andrew Y.Z. Wang** (yzwang@uestc.edu.cn) and **Jean Yeh** (jeanyeh@math.tamu.edu). *On the symmetry of 2-chains in polyominoes*. Preliminary report.

Recently it is observed that the numbers of 2-crossings and 2-nestings have a symmetric joint distribution over many combinatorial structures, including permutations, matchings, set partitions, and linked partitions. These results have been put by Kasraoui in the larger context of enumeration of northeast and southeast chains of size 2 in fillings of moon polyominoes. In this talk we present much stronger symmetric properties of northeast and southeast chains. Our results are obtained by generalizing the polyomino model in two ways: (1) The polyomino is equipped with a charge function, and (2) We relax the constraints on the polyominoes to allow a full action of the symmetric group. This is a joint work with Wang and Yeh. (Received November 28, 2012)

1087-05-80 **Mark Ellingham*** (mark.ellingham@vanderbilt.edu), **Emily Marshall**, **Kenta Ozeki** and **Shoichi Tsuchiya**. *Hamiltonicity of 3-connected planar graphs with a forbidden minor*. Preliminary report.

Tutte showed in 1956 that all 4-connected planar graphs are hamiltonian. But examples of 3-connected planar graphs (or even more specifically, triangulations) that are not hamiltonian have been known since at least the 1930s. So we may ask what additional conditions can be imposed on 3-connected planar graphs to make them hamiltonian. We show that $K_{2,5}$ -minor-free 3-connected planar graphs are hamiltonian. (Received November 28, 2012)

1087-05-85 **Shuchao Li*** (1scmath@mail.ccnu.edu.cn), Faculty of Mathematics and Statistics, Central China Normal University, Wuhan, Hubei 430079, Peoples Rep of China. *Further analysis on the total number of subtrees of trees*.

When considering the total number of subtrees of trees, the extremal structures which maximize this number among binary trees and trees with a given maximum degree lead to some interesting facts that correlate to some other graphical indices in applications. Along this line, it is interesting to study that over some types of trees with a given order, which trees minimize or maximize this number. Here are our main results: (1) The extremal tree which minimizes the total number of subtrees among n -vertex trees with k pendants is characterized. (2) The extremal tree which maximizes (resp. minimizes) the total number of subtrees among n -vertex trees with a given bipartition is characterized. (3) The extremal tree which minimizes the total number of subtrees among the set of all q -ary trees with n non-leaf vertices is identified. (4) The extremal n -vertex tree with given domination number maximizing the total number of subtrees is characterized. (Received November 29, 2012)

1087-05-90 **Xuechao Li*** (xccli@uga.edu), Athens, GA 30602. *New lower bounds on edge critical graphs with small maximum degree from 7-14*. Preliminary report.

Let G be an edge critical graph with maximum degree of $\Delta = 7, \dots, 14$. We are to give some updated adjacency properties on small vertices of G and give new lower bounds for average degree of G . (Received November 29, 2012)

1087-05-94 **Carolyn Chun**, **Dillon Mayhew** and **James Oxley*** (oxley@math.lsu.edu), Mathematics Department, Louisiana State University, Baton Rouge, LA 70803-4918. *Closer Towards a Splitter Theorem for Internally 4-connected Binary Matroids*. Preliminary report.

Two powerful inductive tools for dealing with 3-connected matroids are Tutte's Wheels-and-Whirls Theorem and Seymour's Splitter Theorem. For several years, we have been seeking analogues of these theorems for internally 4-connected binary matroids. In 2011, we proved an analogue of the first theorem by showing that, with some easily described exceptions, it is always possible to remove one, two, or three elements from an internally 4-connected

binary matroid to recover another internally 4-connected matroid. An analogue of the Splitter Theorem seeks not only to retain internal 4-connectivity but also to maintain an isomorphic copy of some internally 4-connected minor N of M . This talk will be a progress report on our work towards such a theorem. (Received November 29, 2012)

1087-05-95 **Jan Draisma, Seth Sullivant*** (smsulli2@ncsu.edu) and **Kelli Talaska**. *Positivity for Gaussian graphical models*.

Gaussian graphical models are parametric statistical models for jointly normal random variables whose dependence structure is determined by a graph. The structure of the resulting random variables are determined by the covariance matrix of the random variables, which is a symmetric positive definite matrix whose entries are rational functions determined by certain directed path systems in the underlying graph. We explain how to expand determinants of submatrices of these matrices in terms of trek systems. The main combinatorial tools used are a generalization of the Gessel-Viennot-Lindstrom Lemma. (Received November 29, 2012)

1087-05-98 **Mark Ellingham, Emily Marshall*** (emily.a.marshall@vanderbilt.edu), **Kenta Ozeki** and **Shoichi Tsuchiya**. *Characterization of $K_{2,4}$ -minor-free graphs*. Preliminary report.

The characterization of all $K_{2,3}$ -minor-free graphs is well-known: 2-connected $K_{2,3}$ -minor-free graphs are either K_4 or outerplanar. In this talk, we provide a characterization of all $K_{2,4}$ -minor-free graphs. For the 3-connected graphs, we have an infinite family which yields $2n - 8$ graphs on n vertices along with some small special examples on at most eight vertices. The 2-connected graphs are then formed by joining the 3-connected ones with outerplanar graphs subject to some restrictions. (Received November 30, 2012)

1087-05-105 **Tri M Lai*** (tmlai@indiana.edu), Department of Mathematics, Indiana University, Rawles Hall, 831 East 3rd Street, Bloomington, IN 47405. *Enumeration of Hybrid Domino-Lozenge Tilings*.

The field of exact enumeration of tilings (equivalently, perfect matchings) dates back to the early 1900's when MacMahon proved his classical theorem on the number of plane partitions. In 1999, James Propp published a famous paper which presented the list of 32 open problems in this field (*New Perspectives in Geometric Combinatorics*, Cambridge University Press). Most of those problems have been solved, but some of them are still open. One of the open problems on the list, Problem 16, asks for the number of tilings of a family of lattice regions, the quasi-hexagons on the square lattice with every third diagonal drawn in. We prove Problem 16 by giving a simple product formula for the number tilings of those regions. We actually define a more general family of regions on the lattice with arbitrary diagonals, and use local transformations (or subgraph replacements) to find their number of tilings. This work also implies a generalization for a theorem of Chris Douglas on a family of regions on square lattice with every second diagonal drawn in. (Received December 01, 2012)

1087-05-136 **Michael D. Plummer*** (michael.d.plummer@vanderbilt.edu), Department of Mathematics, Vanderbilt University, Nashville, TN 37240, **Arthur S. Finbow**, , Canada, and **Bert L. Hartnell**, , Canada. *Well-covered planar quadrangulations*.

A graph is *well-covered* if every maximal independent set of vertices is also maximum. In other words, all maximal independent sets of vertices in the graph have the same cardinality. The recognition problem for well-covered graphs in general belongs to co-NP (in fact it is co-NP-complete), but it is unknown if the problem belongs to NP. Hence the following question is of interest. What interesting subclasses of well-covered graphs can be recognized in polynomial time?

In the present paper, we characterize those planar quadrangulations which are well-covered. This characterization leads to a polynomial algorithm for the corresponding recognition problem. (Received December 02, 2012)

1087-05-140 **Rui Xu*** (xu@westga.edu), University of West Georgia, Carrollton, GA 30135, and **Rong Luo**, West Virginia University, Morgantown, WV 26506. *On Modular- $(2k + 1)$ contractibility and extension consistency*.

Let H be a graph and k be a positive integer. Then H is called Modular- $(2k + 1)$ contractible if for every graph G which contains H as a subgraph, G admits a Modular- $(2k + 1)$ orientation if and only if G/H does; H is called Modular- $(2k + 1)$ extension consistent if for each graph G containing H as a subgraph, any Modular- $(2k + 1)$ orientation of G/H can be extended to a Modular- $(2k + 1)$ orientation of G . We establish the equivalence of these two properties and prove that a graph H is Modular- $(2k + 1)$ contractible if and only if it is Modular- $(2k + 1)$ extension consistent. (Received December 02, 2012)

1087-05-150 **Michael Plummer** (michael.d.plummer@vanderbilt.edu), Department of Mathematica, Vanderbilt University, Nashville, TN 37240, and **Xiaoya Zha*** (xzha@mtsu.edu), KOM 271, Middle Tennessee State University, Murfreesboro, TN 37132. *A weaker version of Robertson's conjecture related to the Petersen graph.*

Robertson conjectured that the only 3-connected internally-4-connected graph of girth 5 in which every odd cycle of length greater than 5 has a chord is the Petersen graph. We provided a counterexample to Robertson's conjecture in an earlier paper. However, we are able to show that Robertson's conjecture is true for many graphs, and any counterexample to Robertson's Conjecture must possess a rather specific structure.

In this talk, we prove a weaker version of Robertson conjecture. We show that if a graph G satisfies the above mentioned properties, then either G is the Petersen graph, or for any 5-cycle C of G , G contains a subgraph that contains C and is isomorphic to the Petersen graph with two edges at distance 2 subdivided. This shows that if G is not the Petersen graph, then for every girth cycle C in G , there is a subgraph H of G which contains C and that is "close to" the Petersen graph. (Received December 03, 2012)

1087-05-157 **Xiangqian Zhou*** (xiangqian.zhou@wright.edu), Dept of Mathematics and Statistics, 3640 Col Glenn Hwy, Dayton, OH 45435, and **Jakayla Robbins** and **Daniel Slilaty**. *Clones in Bicircular Matroids.*

There are two fundamental classes of matroids related to graphs: the well-known one is the class of graphic matroids where a circuit of the matroid is the edge set of a cycle in the graph; the other one is the class of bicircular matroids where a circuit of the matroid is the edge set of a minimal connected subgraph containing at least two cycles of the graph.

Two elements in a matroid are clones if the map that interchanges the two and fixes all other elements is an automorphism of the matroid. Clones have recently become an interesting subject in matroid representation theory. In the talk, we will describe exactly when two elements of a bicircular matroid form a clonal pair. This is joint work with Daniel Slilaty and Jakayla Robbins. (Received December 03, 2012)

1087-05-158 **Jakayla R. Robbins***, jakayla.robbins@vanderbilt.edu, and **Daniel Slilaty**. *A stabilizer theorem for quaternary oriented matroids.*

By now orientations of binary and ternary orientable matroids are well-understood. Much less is known about orientable quaternary matroids. We present a structural result about orientations of quaternary matroids that do not contain a free spike minor. This is joint work with Daniel Slilaty. (Received December 03, 2012)

1087-05-163 **Gábor Hetyei*** (ghetyei@uncc.edu), Department of Mathematics & Statistics, 9201 University City Blvd, Charlotte, NC 28223-0001, and **Sarah Birdsong** (sjbirdso@student.unc.edu), Department of Mathematics & Statistics, 9201 University City Blvd, Charlotte, NC 28223-0001. *Noncrossing partition statistics and the toric h -vector of a cubical complex.*

We express each coordinate of the toric h -vector of a cubical complex, written in the basis of the Adin h -vector entries, as the total weight of all noncrossing partitions in a weighted enumeration model. In our model, the symmetry expressed by the Dehn-Sommerville equations is a consequence of the self-duality of the non-crossing partition lattice, exhibited by the involution of Simion and Ullman. By collecting the appropriate terms we also obtain a new, very simple combinatorial interpretation of the contribution of a shelling component to the toric h -vector of a cubical complex. (Received December 03, 2012)

1087-05-165 **Stefan H.M. van Zwam*** (svanzwam@math.princeton.edu), Fine Hall, Washington Road, Princeton, NJ 08544-1000. *On inequivalent representations.* Preliminary report.

A fascinating, and sometimes frustrating, phenomenon in matroid theory is the fact that genuinely different point configurations in a projective space can still exhibit exactly the same combinatorial properties. Here "genuinely different" means that no projective transformation can turn one configuration into another, and "combinatorial properties" mean that the associated matroids are identical.

The key to controlling this behavior seems to be the notion of connectivity of a matroid. In this talk I will discuss some recent progress in this area. (Received December 03, 2012)

1087-05-174 **Daniel Slilaty*** (daniel.slilaty@wright.edu) and **Jakayla Robbins**. *Some applications of Tutte's homotopy theorem.* Preliminary report.

Two circuits of a matroid M are said to be "adjacent" when they form a modular pair and the restriction of M to the union of these circuits is connected. A "circuit path" is a sequence of circuits where successive circuits in the sequence are adjacent. Given a linear class L of circuits M , a circuit path is "off of L " when all of its circuits

are not in L . Tutte's Homotopy Theorem says that a closed circuit path off of L is constructed from certain small closed circuit paths. We will discuss some applications of Tutte's Theorem. (Received December 03, 2012)

1087-05-181 **Evan J Morgan*** (emorgan@psu.edu), 362 Business Building, Smeal College of Business, University Park, PA 16802, and **Bogdan Oporowski**. *Switches in cubic graphs*.

We define a small, local operation on a general cubic graph called a *switch*. We prove that any two connected, cubic graphs on the same number of vertices are equivalent under the switch relation, and furthermore we may preserve the connectivity, up to internal 4-connectedness, throughout the sequence of switches. (Received December 03, 2012)

1087-05-182 **Guoli Ding*** (ding@math.lsu.edu). *Generating graphs efficiently*. Preliminary report. I will report a splitter-type theorem. (Received December 03, 2012)

1087-05-186 **Anna Lubiw** and **Megan Owen*** (megan.owen@uwaterloo.ca). *Convex Hulls in Tree Space*. Preliminary report.

The space of metric phylogenetic trees, as constructed by Billera, Holmes, and Vogtmann, is a polyhedral cone complex. This space is non-positively curved, so the geodesic (shortest path) between two trees is unique. Based on this property, a number of statistical methods in Euclidean space can be analogously defined for tree space. One such concept is that of convex hulls, which can be used for computing both quartiles of data and data points of maximal depth. We present some preliminary results for characterizing and computing convex hulls in tree space. (Received December 03, 2012)

1087-05-187 **Allan L. Edmonds*** (edmonds@indiana.edu), Department of Mathematics, Indiana University, Bloomington, IN 47405, and **Steven Klee** (klee@seattleu.edu), Department of Mathematics, Seattle University, Seattle, WA 98122. *The combinatorics of hyperbolized manifolds*.

A topological version of a longstanding conjecture of H. Hopf, originally proposed by W. Thurston, states that the sign of the Euler characteristic of a closed aspherical manifold of dimension $d = 2m$ depends only on the parity of m . Gromov defined several hyperbolization functors which produce an aspherical manifold from a given simplicial or cubical manifold. We investigate the combinatorics of several of these hyperbolizations and verify the Euler Characteristic Sign Conjecture for each of them. (Received December 03, 2012)

1087-05-189 **Matthias Beck**, **Felix Breuer**, **Logan Godkin** and **Jeremy L Martin*** (jmartin@math.ku.edu). *Enumerating cellular colorings, orientations, tensions and flows*.

We study the enumeration of colorings, orientations, tensions and flows in an arbitrary pure CW-complex X . These objects are defined via linear algebra and specialize to familiar graph-theoretic definitions in the dimension-1 case. Our results include closed-form and deletion-contraction formulas for the numbers of colorings, tensions and flows of X with values in $\mathbb{Z}/k\mathbb{Z}$ or in $\{0, \pm 1, \dots, \pm k\}$; sufficient conditions for these functions to be polynomials in k ; and reciprocity theorems (i.e., combinatorial interpretations of their evaluations at negative values of k). (Received December 03, 2012)

1087-05-190 **Guantao Chen*** (gchen@gsu.edu), Dept. of Math and Stat, Georgia State University, Atlanta, GA 30303, and **Katshiro Ota**, Department of Mathematics, Keio University. *Hadwiger conjecture for degree sequences*. Preliminary report.

Hadwiger conjectured that every graph contains $K_{\chi(G)}$ as a minor, where $\chi(G)$ is the chromatic number of G . In 2005, Robertson made a weaker conjecture that for any graph G , there exists a graph H with the same degree sequence of G and containing $K_{\chi(G)}$ as a minor, which was confirmed by Dvořák and Mohar recently. In this note, we give a short proof of a result stronger than the original conjecture and independent from the results obtained by Dvořák and Mohar. (Received December 03, 2012)

1087-05-195 **Vladimir Nikiforov***, 373 Dunn Hall, University of Memphis, Memphis, TN 38152. *Spectral problems of Nordhaus-Gaddum type*.

This talk will present recent results about certain sums of eigenvalues of a graph and of its complement. Such problems may be quite difficult to solve and often exhibit relations to other area of mathematics. (Received December 03, 2012)

1087-05-196 **Dong Ye*** (dye@mtsu.edu), Department of Mathematical Sciences, Middle Tennessee State University, Murfreesboro, TN 37132. *Nowhere-zero integer flows in signed graphs*.

A signed graph (G, σ) is a graph G associated with a signature $\sigma : E(G) \rightarrow \{-1, +1\}$. Bouchet's 6-Flow Conjecture states that every signed graph with a nowhere-zero integer flow admits a nowhere-zero 6-flow. In this

talk, we will discuss recent developments in nowhere-zero integer flows in signed graphs. (Received December 03, 2012)

1087-05-198 **Michael Joyce*** (mjoyce3@tulane.edu), Department of Mathematics, 424 Gibson Hall, St. Charles Ave., New Orleans, LA 70118. *Chains in the weak order for twisted involutions and Borel orbits in symmetric spaces.* Preliminary report.

The combinatorics of twisted involutions in Weyl groups and the related posets of Borel orbits in symmetric spaces have been much studied since seminal work by R.W. Richardson and T.A. Springer on the subject. The latter posets describe the (B, K) double cosets of a reductive algebraic group G , where B is a Borel subgroup of G and K is the fixed point subgroup of an involution of G . Work of M. Brion gives two interpretations of the chains in the weak order for these posets: they determine the cohomology classes of K -orbit closures in G/B as well as the restriction to the closed G -orbit of the cohomology classes of B -orbit closures in the wonderful compactification of G/K . In this report, we describe certain subsets of the Weyl group of G whose reduced decompositions parametrize the weak order chains for twisted involutions and Borel orbits in symmetric spaces. (Received December 03, 2012)

1087-05-200 **James Shook*** (james.shook@nist.gov), **Brian Cloteaux**, **Elizabeth Moseman** and **M Drew LaMar**. *Threshold Digraphs.*

A digraph whose degree sequence has a unique vertex labeled realization is called threshold. In this talk I will present several characterizations of threshold digraphs and their degree sequences, and show these characterizations to be equivalent. One of the characterizations is new, and allows for a shorter proof of the equivalence of the two known characterizations as well as proving the final characterization which appears without proof in the literature. Using this result, we obtain a new, short proof of the Fulkerson-Chen theorem on degree sequences of general digraphs. (Received December 03, 2012)

1087-05-201 **Oleg V. Borodin**, **Alexandr V. Kostochka**, **Bernard Bernard Lidický*** (lidicky@illinois.edu) and **Matthew Yancey**. *Short proofs of coloring theorems on planar graphs.*

A recent lower bound on the number of edges in a k -critical n -vertex graph by Kostochka and Yancey yields a half-page proof of the celebrated Grötzsch Theorem that every planar triangle-free graph is 3-colorable. In this talk we use the same bound to give short proofs of other known theorems on 3-coloring of planar graphs, among whose is the Grünbaum-Aksenov Theorem that every planar with at most three triangles is 3-colorable. We also prove the new result that every graph obtained from a triangle-free planar graph by adding a vertex of degree at most four is 3-colorable. (Received December 03, 2012)

1087-05-203 **Josephine Yu***, jyu@math.gatech.edu. *A tropical view on polytopes.*

A polytope is typically described as a convex hull of a finite set points or an intersection of a finite set of halfspaces in a real vector space. I will introduce a *tropical* way to describe polytopes and discuss some applications. In particular, I will talk about tropical descriptions of secondary polytopes, resultant polytopes, and fiber polytopes. (Received December 04, 2012)

1087-05-205 **Alexander R. Miller*** (mill1966@math.umn.edu), School of Mathematics, University of Minnesota, Minneapolis, MN 55455. *On the rank sizes of a differential poset.*

We use two innocent-looking chains in a differential poset to show that the rank sizes are strictly increasing. This answers a question of Stanley and provides evidence in support of a conjecture of the speaker and Reiner which asserts the following strong property for the up and down maps U and D in a differential poset: $DU + tI$ and $UD + tI$ have Smith normal forms over $\mathbb{Z}[t]$. (Received December 04, 2012)

1087-05-206 **Jaromy S Kuhl*** (jkuhl@uwf.edu), 11000 University Parkway, Pensacola, FL 32514. *Competition numbers of complete multipartite graphs.*

Let G denote a simple graph and let I_k denote the graph on k isolated vertices. The competition number of G is the minimum integer k such that $G \cup I_k$ is the competition graph of an acyclic digraph. In this talk, we show that if $n \geq 5$ is odd, then the competition number of the complete tetrapartite graph K_n^4 is at most $n^2 - 4n + 8$. We also show that if n is a prime integer and $m \leq n$, then the competition number of K_n^m is at most $n^2 - 2n + 3$. (Received December 04, 2012)

1087-05-209 **Jacob A White*** (jwhite@math.tamu.edu), Department of Mathematics, Mailstop 3368, Texas A&M University, College Station, TX 77843-3368. *Decision trees, monotone functions, and semi-matroids.*

In *Simplicial Complexes of Graphs*, Jonsson uses decision trees to show that many simplicial complexes are actually wedges of spheres, including semi-matroids. In this talk, we study decision trees for monotone functions on a simplicial complex, and show how these give bounds on relative Betti numbers. We show how some evaluations of the Tutte polynomial of a semi-matroid have topological interpretations as relative Betti numbers, as well as how deletion-contraction can be used to construct decision trees. (Received December 04, 2012)

1087-05-211 **Genghua Fan, Baogang Xu, Tianjun Ye and Xingxing Yu*** (yu@math.gatech.edu). *Forbidden subgraphs and 3-coloring.*

Motivated by Vizing's theorem, Randerath considered the problem of determining pairs of graphs (A, B) such that if a graph G contains neither A nor B as an induced subgraph then $\chi(G) \leq \omega(G) + 1$. In particular, he conjectured that if G is fork-free and triangle-free then $\chi(G) \leq 3$, where a fork is the graph obtained from $K_{1,4}$ by subdividing two edges. We prove this conjecture under the additional condition when G is also C_5 -free. (Received December 04, 2012)

1087-05-213 **Gary Gordon*** (gordong@lafayette.edu), Math Dept, Lafayette College, Easton, PA 18042, and **Jenny McNulty** and **Nancy Neudauer**. *Fixing numbers for graphs and matroids.*

The fixing number of a matroid is the smallest number of elements needed to be fixed so that all remaining matroid automorphisms are trivial. We explore the connections between fixing numbers for graphs and matroids by computing the fixing number for several classes of matroids. (Received December 04, 2012)

1087-05-216 **Hongyu He*** (hongyu@math.lsu.edu), Baton Rouge, LA 70803. *Reconstruction of Graphs and Grassmannian.*

In this talk, I shall relate the reconstruction of graphs to the reconstruction of geometric simplices. I shall give a proof of Tutte's theorem about the reconstructibility of determinant. Then I will formulate a conjecture about the reconstruction of Grassmannian. (Received December 04, 2012)

1087-05-218 **Drew Armstrong*** (armstrong@math.miami.edu), Department of Mathematics, University of Miami, Coral Gables, FL 33146. *Rational Catalan Combinatorics*. Preliminary report.

I will describe the research program of *Rational Catalan Combinatorics*. There are three dimensions of generality: (1) a finite reflection group G , (2) a positive integer p coprime to the Coxeter number h of G , and (3) quantum parameters q and t . For each choice of (G, p) there is (at least) a q -Catalan number

$$\text{Cat}_q(G, p) := \prod_{i=1}^{\ell} \frac{[p-1+d_i]_q}{[d_i]_q} \in \mathbb{N}[q],$$

where $d_1 \leq d_2 \leq \dots \leq d_\ell$ are the "degrees" of G (ignoring some difficulty with non-well-generated complex groups G .) The "origin" of parameter space $(G, p) = (\mathfrak{S}_n, n+1)$ corresponds to objects counted by the classical Catalan numbers $\text{Cat}(\mathfrak{S}_n, n+1) = \frac{1}{n+1} \binom{2n}{n}$. I will discuss recent progress and open problems. (Received December 04, 2012)

1087-05-219 **Perry Iverson*** (piverson@math.lsu.edu) and **Guoli Ding**, Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *A Hall-type result for internally 4-connected projective graphs.*

Hall showed that a 3-connected graph is planar if and only if it has no $K_{3,3}$ minor and is not isomorphic to K_5 . We prove a similar result for internally 4-connected projective graphs. In previous work, we determined the 23 minor-minimal internally 4-connected non-projective graphs, \mathcal{A}'_4 . We first discuss a new splitter-type result for internally 4-connected graphs. Then we use it to find a set $S \subseteq \mathcal{A}'_4$ of minimum size so that an internally 4-connected graph is projective if and only if it is S -free and is not isomorphic to a finite number of exception graphs. (Received December 04, 2012)

1087-05-223 **Emlee W Nicholson*** (nichoe@millsaps.edu). *Degree sum condition for k-ordered hamiltonian connected graphs.*

Let G be a graph on n vertices. If for any ordered set of vertices $S = \{v_1, v_2, \dots, v_k\}$, that is, the vertices in S appear in order of the sequence v_1, v_2, \dots, v_k , there exists a $v_1 - v_k$ (hamiltonian) path containing S in the given order, then G is k -ordered (hamiltonian) connected. Let $\{u_1, u_2\}$ and $\{u_3, u_4\}$ be distinct pairs of nonadjacent vertices. When $G \neq K_n$ and $G \neq K_n - e$, we define $\sigma'_4(G) = \min\{d_G(u_1) + d_G(u_2) + d_G(u_3) + d_G(u_4)\}$, otherwise set $\sigma'_4(G) = \infty$. In this talk, I will present some sufficient conditions for a graph to be k -ordered

connected based on $\sigma'_4(G)$ and, as a main result, if $\sigma'_4(G) \geq 2n + 3k - 10$ ($4 \leq k \leq \frac{n+1}{2}$), then G is k -ordered hamiltonian connected. (Received December 04, 2012)

1087-05-224 **D. Christopher Stephens*** (chris.stephens@mtsu.edu). *On H -graphs and rooted subdivisions of K_4 .*

In 1998, Yu characterized the obstructions to rooted subdivisions of K_4 in 4-connected planar graphs. One of the key steps is the case in which two of the branch vertices are separated from the other two branch vertices by a 4-cut. In this case, the existence of the desired K_4 subdivision depends on the existence of so-called “crossing H -graphs.”

In this talk, we discuss the crossing H -graph problem in the context of 4-connected graphs which are not planar. (Received December 04, 2012)

1087-05-225 **Art Duval*** (artduval@math.utep.edu) and **Ghodratollah Aalipour** (alipour.ghodratollah@gmail.com). *Weighted spanning tree enumerators of complete colorful complexes.* Preliminary report.

A complete colorful complex on r colors is an $(r-1)$ -dimensional simplicial complex whose vertices are partitioned into r disjoint color classes, and whose facets are all the sets (of size r) containing exactly one vertex of each color. Adin enumerated the k -dimensional spanning trees of complete colorful complexes for all $k \leq r$, and Ehrenborg and van Willigenburg counted weighted spanning trees of complete bipartite graphs ($r = 2$). We find a factorization of a weighted enumeration of top-dimensional spanning trees of complete colorful complexes on $r = 3$ and $r = 4$ colors, and we conjecture our technique will extend to all r . The proof relies on the simplicial Matrix-Tree Theorem, and identification of factors, as in Martin and Reiner. (Received December 04, 2012)

1087-05-227 **Kayla D. Harville*** (kddavis1@olemiss.edu), University of Mississippi, **Talmage J. Reid** (mmreid@olemiss.edu), University of Mississippi, and **Haidong Wu** (hwu@olemiss.edu), University of Mississippi. *On Regular and Binary Matroids Without Small Minors.* Preliminary report.

Many important results in combinatorics deal with excluded-minor characterizations of classes of graphs and matroids. One famous example of such a result is Kuratowski’s Theorem which states that a graph is planar if and only if it is $\{K_5, K_{3,3}\}$ -free. Guoli Ding and Cheng Liu have characterized many classes of graphs that are H -free for graphs H with fewer than twelve edges. We have extended some of their results to the class of regular 3-connected matroids.

Dillon Mayhew and Gordon Royle recently characterized the binary internally 4-connected matroids that are prism-free. As an extension of their result, we have determined the binary internally 4-connected matroids that are (prism + e)-free. (Received December 04, 2012)

1087-05-228 **John Shareshian** and **Russ Woodroffe*** (rwoodroffe@math.msstate.edu), Department of Mathematics & Statistics, PO Box MA, Mississippi State, MS 39762. *Homology cycles in the coset posets of certain finite groups.*

For G a finite group, the coset lattice $\mathfrak{C}(G)$ consists of (the empty set together with) all cosets of all subgroups of G , ordered by inclusion. Brown has asked whether there is any group such that the order complex of the coset lattice is contractible. I’ll show how to exhibit explicit homology cycles for the coset poset of certain finite groups: solvable, alternating, and symmetric groups. The symmetric group case naturally gives rise to an intriguing subposet.

I’ll also briefly discuss how this fits in to our recent broader progress on Brown’s Conjecture. (Received December 04, 2012)

1087-05-229 **Arthur S Finbow*** (art.finbow@smu.ca), Department of Mathematics and Computing Sci., Saint Mary’s University, Halifax, N. S. B3H 3C3, Canada, and **Bert L Hartnell**, **Richard J Nowakowski** and **Michael D Plummer**. *The Well-Covered, 3-Connected Triangulations.*

A graph G is said to be *well-covered* if every maximal independent set of vertices has the same cardinality. A plane (simple) graph in which each face is a triangle is called a (plane) *triangulation*. In the first of a sequence of three papers the authors proved that there are no 5-connected plane well-covered triangulations. Clearly, the only plane triangulation which is exactly 2-connected is the triangle K_3 . Two subsequent papers culminated in the proof that there are exactly four well-covered plane triangulations which are exactly 4-connected.

It is the aim of the present paper to complete the characterization of well-covered plane triangulations by characterizing the infinite family of those well-covered triangulations of the plane which are exactly 3-connected. (Received December 04, 2012)

1087-05-230 **Richard Ehrenborg** (jrge@ms.uky.edu), University of Kentucky, Department of Mathematics, Lexington, KY 40506, and **Margaret A. Readdy*** (readdy@ms.uky.edu), University of Kentucky, Department of Mathematics, Lexington, KY 40506. *Manifold arrangements.*

Ehrenborg, Goresky and Readdy have developed a new theory of Euler flag enumeration of Whitney stratified spaces, and more generally, quasi-graded posets. This setting enables them to extend the classical notion of Eulerianness, and show the **cd**-index, a noncommutative polynomial which has been key to understanding the flag vector of polytopes, exists for non-regular CW complexes. Unlike Stanley's nonnegativity result for spherically-shellable posets, the coefficients of the **cd**-index for Whitney-stratified spaces can be negative. We will indicate many open questions. We then focus on the induced subdivision arising from a manifold arrangement. This work shows we can consider manifolds other than the n -sphere (classical arrangements in Euclidean space) and the n -torus, the induced subdivision is a Whitney stratification, and the submanifolds in the arrangement are no longer required to be codimension one. (Received December 04, 2012)

1087-05-231 **Andrew Treglown** and **Yi Zhao*** (yzhao6@gsu.edu). *Minimum degree thresholds for perfect matchings in uniform hypergraphs.*

Given integers $k \geq 3$ and d with $k/2 \leq d \leq k - 1$, we give a minimum d -degree condition that ensures a perfect matching in a k -uniform hypergraph. This is best possible and extends the results of Pikhurko, Rödl, Ruciński and Szemerédi. Our approach makes use of the absorbing method. (Received December 04, 2012)

1087-05-232 **Jackie Kaminski*** (kaminski@math.binghamton.edu), Department of Mathematical Sciences, Binghamton University, PO Box 6000, Binghamton, NY 13902. *Classification of Factored Gain-Graphic Arrangements.*

Determining when an arrangement of hyperplanes is free is a complicated algebraic question, so combinatorial properties and methods are often used to study freeness. One such property is inductive factorization, which implies freeness.

I will introduce arrangements of hyperplanes and a generalization of graphs known as gain-graphs, as well as the notions of factorization and inductive factorization for an arrangement. I will give a classification of all factored gain-graphic arrangements in purely graph theoretic terms, and discuss what remains to be done to extend this classification of factored gain-graphic arrangements to a classification of inductively factored gain-graphic arrangements. (Received December 04, 2012)

1087-05-233 **Stephen G Hartke** and **Derrick Stolee*** (stolee@illinois.edu). *A Branch-and-Cut Strategy for the Manickam-Miklós-Singhi Conjecture.*

The Manickam-Miklós-Singhi Conjecture states that when $n \geq 4k$, every multiset of n real numbers with nonnegative total sum has at least $\binom{n-1}{k-1}$ k -subsets with nonnegative sum. We develop a computational method and verify a stronger statement than the conjecture for k at most 6. Based on these results we formulate a stronger conjecture. (Received December 04, 2012)

1087-05-236 **Jianning Su** (samsu@sccky.edu), 2735 Bardstown Rd, St. Catharine, KY 40061, **Jinko Kanno** (jkanno@latech.edu), P.O. Box 10348, Railroad Ave, Ruston, LA 71272, and **David VanHeeswijk*** (djv003@latech.edu), P.O. Box 10348, Railroad Ave, Ruston, LA 71272. *H-minor free graphs and outerthickness two.*

The *outer-thickness* of a graph G is the smallest number t such that G can be represented as the union of t outer-planar subgraphs. Gonçalves proved that all planar graphs have outer-thickness 2, which is equivalent to saying that graphs that are K_5 and $K_{3,3}$ minor free have outer-thickness 2. We will extend this result to locate other graphs with the property of being H -minor free that have outer-thickness 2. (Received December 04, 2012)

1087-05-237 **Thomas Zaslavsky***, Dept. of Math. Sci., Binghamton University, Binghamton, NY 13902-6000. *Phased Matroids from Gain Graphs.* Preliminary report.

Phased matroids are a complex analog of oriented matroid. Gain graphs are graphs whose edges are invertibly labelled from a group. Gain graphs whose group is that of complex units naturally generate phased matroids which are analogous to graphic matroids. I will report on some aspects of this development.

This is joint work with Laura Anderson. (Received December 04, 2012)

1087-05-238 **Joshua Adam Gray*** (jagray@olemiss.edu), Department of Mathematics, University of Mississippi, Hume Hall 305, University, MS 38677, and **James Reid** and **Xiangqian Zhou**. *Clones and Arcs in Matroids and Projective Spaces*.

Arcs in projective spaces and their bounds have been well studied due to their connections to maximum distance separable codes. Clone sets in matroids have recently been linked to representability over finite fields. Two elements e and f in a matroid M are clones if and only if the mapping that interchanges e and f and fixes all other elements of M is an automorphism. Jakayla Robbins conjectured that the size of a non-trivial clone set in a $GF(q)$ -representable matroid is at most $q - 2$. We will discuss progress towards this bound we have made by examining clone sets in relation to arcs in projective spaces and bounds on the sizes of arcs. (Received December 04, 2012)

1087-05-244 **Michael Schroeder*** (schroederm@marshall.edu), One John Marshall Drive, Huntington, WV 25755, and **Jaromy Kuhl**. *Hamilton Cycle Decompositions of Complete Multipartite Hypergraphs*.

There are many generalizations of a Hamilton cycle (or adjacency in general) to hypergraphs. If G is a r -uniform hypergraph with $V(G) = \{0, 1, 2, \dots, n-1\}$, we define a Hamilton cycle H by a sequence v_0, v_1, \dots, v_{n-1} , where $\{v_i, \dots, v_{i+r}\}$ is an edge for each $i = 0, \dots, n-1$, with arithmetic done modulo n . We show that complete r -partite r -uniform hypergraphs have such a decomposition provided a necessary numerical condition is satisfied. (Received December 04, 2012)

11 ► Number theory

1087-11-21 **Daniel Fiorilli*** (fiorilli@umich.edu). *Elliptic curves of unbounded rank and Chebyshev's bias*.

We establish an equivalence between quantitative unboundedness of analytic ranks of rational elliptic curves and the existence of highly biased elliptic curve prime number races. For this purpose we study the bias in the count of local points of a rational elliptic curve E created by its analytic rank. We show that conditionally on a Riemann Hypothesis and on a hypothesis on the multiplicity of the zeros of $L(E, s)$, large analytic ranks translate into a significant Chebyshev bias. Conversely, we show under a linear independence hypothesis that if highly biased elliptic curve prime number races do exist, then the Riemann Hypothesis holds for infinitely many elliptic curve L -functions and there exists elliptic curves of arbitrarily large rank. (Received December 04, 2012)

1087-11-30 **Ian Petrow*** (ipetrow@math.stanford.edu), 450 Serra Mall, Building #380, Stanford, CA 94305. *Moments of L -functions and Random Matrix Theory*.

A classical method for studying L -functions in families is to consider their k -th power averages over the family, which we call the k -th moment. Based on the idea that there should exist a "spectral interpretation" for L -functions, random matrix theory has been introduced in past 10 years or so to make precise conjectures for asymptotic estimates of moments of L -functions. In this talk, we will present some new results on moments in a case where the family of L -functions has odd orthogonal symmetry. (Received November 10, 2012)

1087-11-35 **Kevin Ford*** (ford@math.uiuc.edu), Department of Mathematics, 1409 West Green St., University of Illinois, Urbana, IL 61802. *Sieving very thin sets of primes*.

We discuss a new method to bound the number of primes in certain very thin sets. For each prime p , only 1 or 2 residue classes modulo p are omitted, and so the traditional small sieve produces poor bounds. The sets S under consideration have the property that if $p \in S$ and $q|(p-1)$, then $q \in S$. We prove that either S contains all primes or $\#\{p \in S : p \leq x\} = O(x^{1-c})$ for some positive c . We describe applications of such prime sets to Carmichael's conjecture, iterates of arithmetic functions and recent work of the speaker, Konyagin and Luca on groups with Perfect Order Subsets. (Received November 15, 2012)

1087-11-47 **Tsz Ho Chan*** (tchan6174@gmail.com), Victory University, 255 N. Highland Street, Memphis, TN 38111, and **Kai-Man Tsang**. *Squarefull numbers in arithmetic progressions*.

In this talk, we will discuss about the distribution of squarefull numbers in arithmetic progressions. The tools range from Dirichlet's hyperbola method to Burgess' bound to a large sieve inequality of Heath-Brown. (Received November 21, 2012)

1087-11-59 **Adam J. Harper*** (harperad@crm.umontreal.ca). *Inverse questions for the large sieve.*
 The large sieve inequality implies that if one takes the integers less than x , and removes around half of the residue classes modulo each prime, then the resulting set must have size $\ll \sqrt{x}$. This bound is sharp in the case where one removes the quadratic non-residues modulo each prime, in which case the set of squares is left behind. The inverse conjecture for the large sieve proposes, amongst other things, that there are no essentially different examples where this bound is sharp.

In this talk I will indicate how, by combining the large sieve, the larger sieve, and some basic ideas from additive combinatorics, one can prove some results in the direction of the inverse conjecture. This is joint work with Ben Green. (Received November 25, 2012)

1087-11-64 **Caroline L. Turnage-Butterbaugh*** (clbutter@go.olemiss.edu), University, MS 38677. *Moments of Products of L-functions.* Preliminary report.

Assuming some standard conjectures, I will discuss how to estimate continuous moments of arbitrary products of (primitive) L-functions from the Selberg class. Time permitting, I will also discuss an application to the zero distribution of Dedekind zeta-functions of quadratic number fields. (Received November 26, 2012)

1087-11-68 **Maksym Radziwill*** (maksym@stanford.edu). *Zeros of ζ , of ζ' , and of Siegel.*

The distribution of the zeros of the derivative of the Riemann zeta-function seems to depend on the distribution, both horizontal and vertical, of the zeros of the Riemann zeta-function. Motivated by applications to the class number problem and the non-existence of Siegel zeros, Farmer and Ki have recently conjectured a precise relationship between the distribution of these two sets of zeros. I will describe the ideas behind my proof of Farmer and Ki's conjecture, the connection between the distribution of these three sets of zeros (ζ , ζ' and Siegel) and the relevance of each set of zeros to number-theoretic problems. I will argue that the three sets are best understood when their inter-relationships are exploited. (Received November 27, 2012)

1087-11-71 **J Brian Conrey*** (conrey@aimath.org), 360 Portage Ave, Palo Alto, CA 94306. *The combinatorics of n-correlation.*

The zeros of the Riemann zeta-function are spaced like the eigenvalues of unitary matrices, as seen from Montgomery's work on the pair correlation of the zeros and from Rudnick and Sarnak's work on the n-correlation. The combinatorics in the latter paper to make this connection are somewhat roundabout. In joint work with Nina Snaith we give a new natural approach to unravel these combinatorics. (Received November 27, 2012)

1087-11-74 **Thai Hoang Le*** (1eth@math.utexas.edu) and **Craig Spencer**. *Intersective polynomials and Diophantine approximation.*

It has been known since Vinogradov that for each k , there is an exponent $\theta = \theta(k)$ such that for every positive integer N and real number α , we have $\min_{1 \leq n \leq N} \|\alpha n^k\| \ll N^{-\theta}$, the bound being uniform in α and N (where $\|\cdot\|$ denotes the distance to the nearest integer). More generally, there is an exponent $\theta = \theta(k, l)$ such that for any polynomials f_1, \dots, f_l of degree at most k and with zero constant terms, we have $\min_{1 \leq n \leq N} \|\max_{1 \leq i \leq l} f_i(n)\| \ll N^{-\theta}$, the bound being uniform in the coefficients of f_1, \dots, f_l . Much effort has been put in finding best possible exponents. In joint work with Craig Spencer, we generalize further the above results, replacing each monomial n^k by a polynomial in $\mathbf{Z}[x]$. It turns out that the only obstructions to the above inequalities are of local nature. (Received November 27, 2012)

1087-11-87 **Paul Pollack*** (pollack@uga.edu), Boyd Graduate Studies Building, Department of Mathematics, Athens, GA 30602. *Prime splitting in abelian number fields.*

In 1966, Linnik and Vinogradov showed that the smallest prime quadratic residue modulo p is, for large primes p , of size no more than roughly $p^{1/4}$. This was generalized by Elliott five years later: Fix $k \geq 2$. For primes $p \equiv 1 \pmod{k}$, the least prime k th power residue mod p is no more than about $p^{(k-1)/4}$. In this talk, we present a further generalization, estimating from above the least prime which splits in a prescribed way in an abelian extension K/\mathbf{Q} . The Elliott–Linnik–Vinogradov results correspond to looking for a split-completely prime when K/\mathbf{Q} is cyclic of prime conductor. (Received November 29, 2012)

1087-11-89 **Joseph A Vandehey*** (vandehe2@illinois.edu), Department of Mathematics, 1409 W Green Street, Urbana, IL 61801. *Exponential sums, the van der Corput transform, and Cornu spirals.*

The van der Corput transform (also known as process B in the theory of exponent pairs) can take a difficult exponential sum, $\sum g(n) \cdot \exp(2\pi i f(n))$, and return a new exponential sum that is—hopefully—more easily estimated. However, this transform comes at the cost of a large error as well as restrictive conditions on the functions f and g . We will present new results which give the leading term of the error explicitly and can also

be applied to many more general sums. These results help to explain the beautiful spirals that appear when the partial sums of an exponential sum are plotted. (Received November 29, 2012)

1087-11-91 **Riad Masri*** (masri@math.tamu.edu). *Harmonic weak Maass forms and the partition function.*

Recently, Bruinier and Ono discovered a finite algebraic formula for the Hardy-Ramanujan partition function $p(n)$. Starting with this formula, we will explain how methods from the spectral theory of automorphic forms can be used to obtain a new asymptotic formula for $p(n)$ with a power saving in the error term. (Received November 29, 2012)

1087-11-93 **Chantal David** and **Ethan Smith*** (ecsmith13@liberty.edu). *Group structures of elliptic curves over finite fields, II.*

If E is an elliptic curve over the finite field \mathbb{F}_p , then it is well known that as an abstract group $E(\mathbb{F}_p) \simeq \mathbb{Z}/m\mathbb{Z} \times \mathbb{Z}/mk\mathbb{Z}$ for some unique positive integers m and k . Given a group G of this shape, we consider the problem of determining the frequency to which the group G arises as the group of points on some elliptic curve over some prime finite field. Conditional upon a certain hypothesis concerning the distribution of primes in short intervals, we show an asymptotic formula for this problem when the exponent of the group is not too small compared to the size of the group. This is joint work with Chantal David. Time permitting, I will also briefly discuss recent progress (with V. Chandee, C. David, and D. Koukoulopoulos) on some unconditional results related to this problem. (Received November 29, 2012)

1087-11-96 **Benjamin Linowitz** and **Lola Thompson*** (lola@math.uga.edu). *The sign changes of Fourier coefficients of Eisenstein series.*

We study a variety of statistical questions concerning the signs of the Fourier coefficients of Eisenstein series, proving analogues of several well-known theorems for cusp forms. (Received November 30, 2012)

1087-11-99 **Vorrapan Chandee**, **Chantal David**, **Dimitris Koukoulopoulos*** (koukoulo@dms.umontreal.ca) and **Ethan Smith**. *Group structures of elliptic curves over finite fields, I.*

It is known that an elliptic curve E over a finite field \mathbb{F}_p admits a group structure which is abelian and has rank at most 2. Therefore there are integers m and k such that the group of points of E over \mathbb{F}_p is isomorphic to $\mathbb{Z}/m\mathbb{Z} \times \mathbb{Z}/mk\mathbb{Z}$. In the converse direction, Rück characterized which pairs of integers (m, k) can arise this way. It is then natural to ask how many of such pairs exist with $m \leq M$ and $k \leq K$. Call the number of such pairs $S(M, K)$. Banks, Pappalardi and Shparlinski studied the size of $S(M, K)$, which they related to a problem about the existence of primes in short arithmetic progressions. Based on standard heuristics about primes, they made a conjecture about the size of $S(M, K)$ and proved some partial results towards it. In this talk, I will discuss recent progress in this problem which leads to an improvement of the results of Banks, Pappalardi and Shparlinski, as well as to a proof of their conjecture in certain ranges of M and K . This is joint work with V. Chandee, C. David and E. Smith. (Received November 30, 2012)

1087-11-109 **Jing-Jing Huang*** (huang@math.toronto.edu), University of Toronto, 40 St. George St., Toronto, Ontario M5S 2E4, Canada. *The distribution of rational points near planar curves and metric Diophantine approximation.*

In 1998, Kleinbock and Margulis established the fundamental Baker-Sprindžuk conjecture that non-degenerate analytic manifolds are extremal. Subsequently, the much stronger Khintchine-Jarník type theorem for non-degenerate planar curves has been established—thanks to Vaughan and Velani for the convergence theory and Beresnevich, Dickinson and Velani for the divergence theory. Though, both approaches rely on estimates on the number of rational points with small denominators which are “close” to the curve, the two proofs differ quite significantly in nature. In this talk, an approach towards a unified proof of the counting problem and some applications to metric Diophantine approximation on manifolds will be discussed. (Received November 30, 2012)

1087-11-128 **S. Ali Altug*** (altug@math.columbia.edu). *A New Analytic Approach to the Trace Formula.*

The Arthur-Selberg trace formula, which relates the spectral properties of a group to its geometry, is a main tool in the theory of automorphic representations. It has been used successfully in the context of comparing spectra of different groups to get cases of Langlands functoriality. However, (as noted by Langlands himself) most cases of functoriality fall out of this scope and one is naturally lead to investigate other methods to analyze automorphic representations. In this talk we will report on recent ongoing work of the speaker on a new analytic approach

to the trace formula on $GL(2)$, which allows one to use it in a non comparative way to analyze automorphic representations and their functorial lifts. (Received December 01, 2012)

1087-11-154 **Bill Mance*** (mance@unt.edu), Department of Mathematics, General Academics Building 435, 1155 Union Circle #311430, Denton, TX 76203-5017. *The Hausdorff dimension of certain sets of normal numbers with respect to the Cantor series expansions.*

We will discuss three notions of normality with respect to the Q -Cantor series expansion: Q -normality, Q -ratio normality, and Q -distribution normality. These notions are equivalent for the b -ary expansions, but constructions exist which show their non-equivalence for many Q -Cantor series expansions. We will examine recent constructions of sets of numbers that are Q -distribution normal, but not Q -ratio normal that have full Hausdorff dimension. Even more surprising is that the countable intersection of many families of sets of this form still has full Hausdorff dimension. (Received December 03, 2012)

1087-11-159 **Matthew P Young*** (myoung@math.tamu.edu). *Restrictions of automorphic forms and L -functions.*

I will discuss recent progress on some questions about automorphic forms having the common theme that one begins with an automorphic form on some space, and then one wishes to understand its behavior when restricted to a natural subspace. Does the form vanish along this subspace? How large can it be? These types of questions have connections to mathematical physics (quantum chaos), representation theory, and geometry. I will talk about some particularly nice examples where these investigations lead naturally to families of L -functions, where tools from analytic number theory play a crucial role. These are joint works with Valentin Blomer, Rizwan Khan, Xiaoqing Li, Sheng-Chi Liu, and Riad Masri, in various combinations. (Received December 03, 2012)

1087-11-162 **Steve Gonek*** (gonek@math.rochester.edu), Department of Mathematics, University of Rochester, Rochester, NY 14627. *Finite Euler product approximations of the Riemann zeta-function.*

If one could construct a model of the Riemann zeta-function that incorporates its basic properties but has a more transparent structure, this could lend insight into the zeta-function's behavior. I will describe the construction of a family of functions out of finite Euler products and any zeros the zeta-function might have to the right of the critical line. I will then discuss how well these functions approximate the zeta-function both on the Riemann Hypothesis and unconditionally. (Received December 03, 2012)

1087-11-170 **Roman Holowinsky***, 231 W 18th Ave, 100 Math Tower, Columbus, OH 43210. *The subconvexity problem for Rankin-Selberg convolutions.* Preliminary report.

We will discuss several new approaches to the subconvexity problem for Rankin-Selberg convolutions. This is a summary of ongoing work with several authors including Nicolas Templier (Princeton) and Ritabrata Munshi (TIFR). (Received December 03, 2012)

1087-11-175 **Robert J Lemke Oliver*** (rlemkeo@emory.edu). *Multiplicative functions dictated by Artin symbols.*

Granville and Soundararajan have recently put forward the notion that generic multiplicative functions deserve greater study in the area of analytic number theory. Here we study such functions which arise from the arithmetic of number fields. For each finite Galois extension K/\mathbb{Q} , we construct a natural class \mathcal{S}_K of completely multiplicative functions whose values are dictated by Artin symbols, and we show that the only functions in \mathcal{S}_K exhibiting greater than expected cancellation are Dirichlet characters. (Received December 03, 2012)

1087-11-176 **Karl Mahlburg*** (mahlburg@math.lsu.edu). *Asymptotic behavior of unimodal sequences.*

A sequence of positive integers is unimodal if the entries are initially monotonically increasing until a peak value is reached, and are subsequently monotonically decreasing. These sequences and their variants have been studied for their interest in combinatorics, the theory of partitions, and statistical mechanics. The main results presented in this talk will address the asymptotic analysis of unimodal sequences, and the relationship to recent developments in the theory of mock modular forms, meromorphic Jacob forms, and false theta functions. (Received December 03, 2012)

12 ► *Field theory and polynomials*

1087-12-49 **Cemile Tosun*** (ctosun@siu.edu), Southern Illinois University Carbondale. *Explicit Factorizations of Generalized Cyclotomic Polynomials.*

We give explicit factorizations of generalized a -cyclotomic polynomials of order $3 \cdot 2^m$, into a product of irreducible polynomials for any nonzero a over a finite field F_q . (Received November 22, 2012)

13 ► *Commutative rings and algebras*

1087-13-10 **Haohao Wang*** (hwang@semo.edu), Math Department, MS6700, One University Plaza, Cape Girardeau, MO 63701, and **William Hoffman.** *Rees Algebra of Quadratically Parametrized Surfaces.*

Let f_0, f_1, f_2, f_3 be linearly independent homogeneous quadratic forms in the standard \mathbb{Z} -graded ring $R := \mathbb{K}[s, t, u]$, and $\gcd(f_0, f_1, f_2, f_3) = 1$. This defines a rational map $\phi : \mathbb{P}^2 \rightarrow \mathbb{P}^3$. The Rees algebra $\text{Rees}(I) = R \oplus I \oplus I^2 \oplus \dots$ of the ideal $I = \langle f_0, f_1, f_2, f_3 \rangle$ is the graded R -algebra which can be described as the image of an R -algebra homomorphism $h: R[x, y, z, w] \rightarrow \text{Rees}(I)$. This paper discusses the free resolutions of I , and the structure of the $\ker(h)$. (Received October 09, 2012)

1087-13-26 **Stephen P Sturgeon*** (stephen.sturgeon@uky.edu). *Cellular Resolutions of Stacked Polytopes.* Preliminary report.

A common object of interest in the study of ideals is the free resolution of quotient rings. For some monomial ideals we can encode all the information of the free resolution in a cell complex. In this talk we construct a class of polytopes with several desirable qualities (integer embedding, polar self-dual, easily described face structure) that support the minimal free resolution of Stanley-Reisner rings arising from stacked polytopes. This is an interesting case as it is non-linear and Gorenstein. In the construction we use algebraic techniques coupled with geometric interpretations to find the desired polytope. (Received November 09, 2012)

1087-13-27 **Paul C. Roberts*** (roberts@math.utah.edu), Department of Mathematics, University of Utah, 155 S 1400 E, Rm. 233, Salt Lake City, UT 84112-0090. *Local cohomology of Segre product type rings.*

Many of the simple examples on normal non-Cohen-Macaulay domains can be constructed using Segre products. In this talk we first state the general question of almost killing local cohomology of non-Cohen-Macaulay rings in finite extensions. We then explain how this can be done for a very general class of mixed characteristic rings defined using Segre products. (Received November 09, 2012)

1087-13-39 **Hariharan Ananthnarayan** and **Ela Celikbas*** (celikbase@missouri.edu), 109A Math Sciences Bldg, Mathematics Department, University of Missouri, Columbia, MO 65203, and **Zheng Yang.** *Decomposing Gorenstein rings as Connected Sums.* Preliminary report.

For Gorenstein Artin k -algebras R and S where k is a field, the connected sum, $R \#_k S$, is a quotient of the classical fiber product $R \times_k S$. We show that certain Gorenstein local k -algebras decompose as connected sums. We generalize structure theorems given by Sally, Elias and Rossi that show two types of Gorenstein local k -algebras are connected sums. (Received November 19, 2012)

1087-13-41 **Jinjia Li*** (jinjia.li@louisville.edu), Department of Mathematics, 328 Natural Science Building, University of Louisville, Louisville, KY 40292. *Socle of Frobenius and Hilbert-Kunz multiplicity for curves.*

Suppose R is a two-dimensional standard graded local normal domain in positive characteristic p and I is a homogeneous ideal primary to the maximal ideal. We show that the distribution of the socle degrees of $R/I^{[p^e]}$ is very much related to the asymptotic slopes of the syzygy bundle of I , which are known to determine the Hilbert-Kunz multiplicity of I . As a result, we show the diagonal F -threshold of I is always a rational number in such a case. (Received November 17, 2012)

1087-13-52 **Susan Marie Cooper*** (s.cooper@cmich.edu), Department of Mathematics, Central Michigan University, Mt. Pleasant, MI 48859, and **Elena Guardo** (guardo@dmi.unict.it), Dipartimento di Matematica e Informatica, Università di Catania, Viale A. Doria, 6, I-95125 Catania, Italy. *Partial Intersections and Fat Points.* Preliminary report.

Despite the fact that Hilbert functions of reduced points are well-understood, there is yet much work to be done for Hilbert functions of fat points. For example, there is a formula which relates the Hilbert functions of a reduced complete intersection, a subset and its complement inside the complete intersection. Does a similar

formula exist for non-reduced points? In this talk we will relate Hilbert functions of fat points supported inside certain complete intersections to Hilbert functions of reduced point sets called partial intersections. (Received November 24, 2012)

1087-13-56 **Lee Klingler*** (klingler@fau.edu), Department of Mathematical Sciences, Florida Atlantic University, Boca Raton, FL 33431, and **Yuri Villanueva**. *Rings of integer-valued polynomials and derivatives*. Preliminary report.

Gilmer and Smith showed that the ring $\text{Int}(\mathbb{Z}) = \{f \in \mathbb{Q}[X] \mid f(\mathbb{Z}) \subseteq \mathbb{Z}\}$ of integer-valued polynomials on \mathbb{Z} has the 2-generator property; that is, every finitely generated ideal of $\text{Int}(\mathbb{Z})$ can be generated by two elements. We extend this result to more general domains D and more general rings of integer-valued polynomials. Using ideas of Cahen and Chabert, we show that, if D is a Noetherian, locally analytically irreducible domain with finite residue fields, and if D has the m -generator property, then the ring $\text{Int}^{(r)}(D) = \{f \in K[X] \mid f^{(k)}(D) \subseteq D \text{ for all } 0 \leq k \leq r\}$ of integer-valued polynomials and derivatives (up to order r) has the $((r+1)m+1)$ -generator property, where K is the field of fractions of D . (Received November 25, 2012)

1087-13-86 **Kazuma Shimomoto*** (shimotokazuma@gmail.com), Department of Mathematics, Meiji University, 1-1-1 Higashimita Tama-Ku, Kawasaki, 214-8571, Japan, and **Tadashi Ochiai**, Osaka University. *Characteristic ideals and torsion modules arising from Iwasawa theory and modular forms*.

In this talk, we discuss various algebraic invariants attached to certain torsion modules defined over normal domains such as Hecke algebras or deformation rings associated to Galois representations. In particular, we give a criterion for divisibility of these algebraic invariants by Bertini theorem on local rings. (Received November 29, 2012)

1087-13-112 **Mats Boij, Juan Migliore, Rosa M Miró-Roig and Uwe Nagel*** (uwe.nagel@uky.edu), Department of Mathematics, University of Kentucky, 715 Patterson Office Tower, Lexington, KY 40506-0027, and **Fabrizio Zanello**. *On the Weak Lefschetz Property for Artinian Gorenstein algebras*. Preliminary report.

We discuss the problem of whether an arbitrary height three graded artinian Gorenstein algebra has the Weak Lefschetz Property. We reduce this problem to checking whether it holds for all compressed Gorenstein algebras of odd socle degree. Then we consider the first open case, namely Hilbert function $(1, 3, 6, 6, 3, 1)$.

This is joint work with Mats Boij, Juan Migliore, Rosa M. Miró-Roig, and Fabrizio Zanello. (Received November 30, 2012)

1087-13-134 **Sema Gunturkun*** (gunturkun@ms.uky.edu) and **Uwe Nagel**. *Boij-Söderberg Decomposition of the Betti Diagrams of Lex-segment Ideals*. Preliminary report.

Boij-Söderberg theory describes the Betti diagrams of graded modules over the polynomial ring as a linear combination of pure (normalized) diagrams with positive coefficients. In this talk, we will focus on Betti diagrams of lex-segment ideals and study Boij-Söderberg decomposition of their Betti diagrams in terms of Boij-Söderberg decomposition for some larger lex-segment ideals. (Received December 02, 2012)

1087-13-138 **Livia Hummel*** (hummell@uindy.edu). *Homological Perspectives on Coherent Rings*.

The theories of coherent Cohen-Macaulay and Gorenstein rings developed by Hamilton and Marley, and Hummel and Marley, respectively, are built upon a homological framework. This talk will explore connections between developments in the theory of homological dimensions and the theory of coherent Gorenstein rings. (Received December 02, 2012)

1087-13-141 **Florian Enescu*** (fenescu@gsu.edu), Dept of Mathematics and Statistics, Georgia State University, Atlanta, GA 30303. *A new class of strong test ideals*. Preliminary report.

In this talk I will discuss the notion of strong test ideal in tight closure theory and provide a new class of such ideals. I will also present the status of a related open problem on the parameter test ideal. (Received December 02, 2012)

1087-13-155 **Andrew R. Kustin*** (kustin@math.sc.edu), Math. Dept., University of South Carolina, Columbia, SC 29208, and **Claudia Polini** and **Bernd Ulrich**. *Rees Algebras and Singularities*.

Consider the rational plane curve \mathcal{C} parameterized by $\eta = [h_1 : h_2 : h_3] : \mathbb{P}^1 \rightarrow \mathbb{P}^2$, where the h_i are homogeneous forms of degree d in $k[x, y]$. (We may harmlessly assume that η is base point free and birational onto its image.) The graph of η contains more information than the image of η and the bi-homogeneous coordinate ring of the graph of η is the Rees-algebra, \mathcal{R} , associated to the ideal generated by the h 's. We give explicit formulas for the

defining equations of \mathcal{R} when \mathcal{C} has a singularity of multiplicity $d - 2$. We also give the bi-degrees of a minimal generating set for a truncation of the defining ideal of \mathcal{R} , whenever \mathcal{C} has a singularity of multiplicity more than $d/2$. (Received December 03, 2012)

1087-13-161 **Adela Vraciu*** (vraciu@math.sc.edu). *Relations of small degree in positive characteristic*. Preliminary report.

Let k be a field of positive characteristic. We give a formula for the smallest degree of a relation on $x_1^{d_1}, \dots, x_n^{d_n}$, $(x_1 + \dots + x_n)^{d_{n+1}} \in k[x_1, \dots, x_n]$. This is less than or equal to the corresponding degree in characteristic zero.

This is related to the weak Lefschetz property for the ring $k[x_1, \dots, x_{n+1}]/(x_1^{d_1}, \dots, x_{n+1}^{d_{n+1}})$ in positive characteristic. We can also use our formula to find the top socle degree of Frobenius powers of the maximal ideal in the ring $k[x_1, \dots, x_n]/(x_1^d + \dots + x_n^d)$. (Received December 03, 2012)

1087-13-166 **Greg Piepmeyer*** (ggpz95@mail.missouri.edu) and **Olgur Celikbas**. *Syzygies and tensor products*.

We consider a question coming from results of Auslander, Huneke and R. Wiegand.

Let R be a commutative Noetherian local ring and let M and N be finitely generated nonzero R -modules. If the tensor product of M and N is an n th syzygy, is M or N ?

The answer is no generally, but the question is open for complete intersection rings, even for hypersurface domains. Work with Olgur Celikbas makes use of the New Intersection Theorem to obtain an affirmative answer.

Assume R is a complete intersection of codimension c and that the tensor product of M and N is an $(n+c)$ th syzygy module. Then both M and N are n th syzygy modules provided that they are Tor independent. (Received December 03, 2012)

1087-13-167 **Melvin Hochster** and **Yongwei Yao*** (yyao@gsu.edu). *Splitting, strong F-regularity, and small CM modules*.

This is joint work with M. Hochster. Let R be a Noetherian ring of prime characteristic $p > 0$ that is F -finite, and M a finitely generated R -module. For every integer $e \geq 0$, there is an induced R -module, denoted eM , via the Frobenius map $F^e: R \rightarrow R$.

We prove that certain assumptions involving strong F -regularity will guarantee that eM will split non-trivially. Conversely, splitting of R off eM , if this happens frequently enough, implies strong F -regularity. Finally, we prove that enough direct summands of eM imply the existence of small Cohen-Macaulay modules. (Received December 03, 2012)

1087-13-178 **Sara L. C. Malec*** (smalec@gsu.edu), Department of Mathematics and Statistics, 30 Pryor St, Atlanta, GA 30303. *On the intersection algebra of principal ideals*. Preliminary report.

Given two ideals in a Noetherian ring R , the intersection algebra is an object that captures some information on the relationships between those two ideals. In this talk, we use a connection to semigroup rings to describe some properties of the intersection algebra, including an algorithm that produces its generating set. (Received December 03, 2012)

1087-13-183 **Gemma Colome-Nin**, IN, **Claudia Polini**, IN, **Bernd Ulrich**, IN, and **Yu Xie*** (xieyucn@gmail.com), Department of Mathematics, Georgia State University, Atlanta, GA 30303. *Generalized Hilbert functions and normalization of ideals*.

Let (R, m) be a Noetherian local ring and I an R -ideal. One defines the generalized Hilbert function and generalized Hilbert coefficients of I using the 0-th local cohomology functor. In joint work with Colome-Nin, Polini and Ulrich, we study the properties of generalized Hilbert functions and use the first generalized Hilbert coefficient to bound the number of steps of algorithms that build the integral closure of I . (Received December 03, 2012)

1087-13-191 **Sarah Mayes*** (mayess@umich.edu). *The asymptotic behavior of generic initial systems*.

A "generic initial system" is a graded system of ideals consisting of the generic initial ideals of powers of a fixed homogeneous ideal. It turns out that the limiting behavior of the generic initial system can be extremely nice, even though its individual ideals have a complicated structure. The purpose of this talk will be to introduce generic initial systems, outline some related research questions, and provide answers to these questions for the case of complete intersections and ideals of points in the projective plane. (Received December 03, 2012)

1087-13-212 **Christina L. Eubanks-Turner*** (ceturner@louisiana.edu), P.O. Box 41010, Lafayette, LA 70503, and **Aihua Li**. *The Graph of $\text{Spec}(\mathbb{Z}[x])$* .

In this work we investigate the graphical properties of the bipartite subgraph of $\text{Spec}(\mathbb{Z}[x])$. By approaching prime spectra from a new perspective we hope to gain more insight about the ring. We have results concerning such fundamental graph theoretical properties as connectivity, girth, diameter and circumference for the bipartite subgraph of $\text{Spec}(\mathbb{Z}[x])$. As the graph associated with $\text{Spec}(\mathbb{Z}[x])$ is an infinite graph, we consider some infinite graph theory aspects of the spec graph like homogeneity and ray behavior. (Received December 04, 2012)

1087-13-217 **J Brett Barwick*** (bbarwick@uscupstate.edu). *Computing Buchsbaum-Eisenbud Matrices for Homogeneous Grade Three Gorenstein Ideals in $k[x, y, z]$* . Preliminary report.

Let $R = k[x, y, z]$ with k a field and let $I \subseteq R$ be a homogeneous grade 3 Gorenstein ideal (i.e., R/I is a Gorenstein ring). The Buchsbaum-Eisenbud Structure Theorem for grade three Gorenstein ideals shows that there exists an alternating presentation matrix ψ whose signed maximal order Pfaffians are the generators of the ideal I , up to multiplication by a unit. We will call such a matrix ψ a Buchsbaum-Eisenbud matrix for the given generating set. We describe an algorithm which can be used to compute such an alternating presentation matrix, which will not typically be produced when computing a free resolution using standard Gröbner basis techniques. (Received December 04, 2012)

1087-13-239 **Augustine O’Keefe*** (abok222@uky.edu) and **Uwe Nagel**. *Invariants of Riemann-Roch monomial ideals*. Preliminary report.

In a recent paper Manjunath and Sturmfels define a special class of artinian monomial ideals for which a Riemann-Roch type formula holds. In this talk we will discuss algebraic invariants of these monomial ideals arising from its minimal free resolution. (Received December 04, 2012)

1087-13-248 **Joseph P. Brennan***, Department of Mathematics, University of Central Florida, Orlando, FL 32816. *Syzygies of monomial algebras associated to graphs*. Preliminary report.

We present recent results on the structure of the syzygies of monomial algebras associated to normal graphs. (Received December 05, 2012)

14 ► Algebraic geometry

1087-14-88 **Megan Patnott*** (mpatnott@nd.edu). *Arithmetically Gorenstein sets of points on general surfaces in \mathbb{P}^3* .

We discuss the possible h-vectors of arithmetically Gorenstein sets of points on a general surfaces in \mathbb{P}^3 . We will focus on the existence of such sets of points for each possible h-vector on a general sextic surface, but will also discuss some partial results for general surfaces of higher degree and for the possible graded Betti numbers of arithmetically Gorenstein sets of points on a general quintic surface. Our methods are centered on the vector bundle techniques developed by several people, notably Chiantini and Faenzi, together with extensive use of liaison theory. (Received November 29, 2012)

1087-14-177 **Justin Allman*** (jallman@email.unc.edu) and **Richard Rimanyi**. *A generating sequence for K -theoretic quiver polynomials*. Preliminary report.

Quiver polynomials measure the degeneration of diagrams of bundle maps. An explicit algebraic combinatorial algorithm for computing K -theoretic quiver polynomials for Dynkin quivers has been given by A. Buch in terms of stable Grothendieck polynomials. He conjectures that the coefficients have alternating signs. We will sketch the highlights of Buch’s method, and propose a new formula in terms of generating sequences, which has more promise to prove the positivity conjecture. (Received December 03, 2012)

16 ► Associative rings and algebras

1087-16-2 **Daniel R Krashen*** (dkrashen@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30606. *Topology, arithmetic, and the structure of algebraic groups*.

Linear algebraic groups are the source of a number of important constructions in a variety of areas, including geometry, number theory and topology. The structure of these groups is intimately related to such structures as central simple algebras, algebras with involution, quadratic forms and hermitian forms. It is not surprising

perhaps, that the study of such structures can involve a beautiful and subtle interplay between techniques from a variety of different areas of mathematics.

In this talk, I will focus on the study of central simple algebras. After relating these objects to linear algebraic groups, I will describe some questions of current interest, and try to explain the ways in which techniques from homotopy theory, arithmetic and algebraic geometry have been brought to bear on them. (Received December 04, 2012)

18 ► *Category theory; homological algebra*

1087-18-11 **Furuzan Ozbek*** (furuzanozbek@uky.edu), 718 Patterson Office Tower, Lexington, KY 40508. *Subfunctors of Ext^1 and their properties (Preliminary Report)*. Preliminary report.

In an arbitrary ring R , a precovering class \mathcal{P} which contains all the projective R -modules gives us a subfunctor $Ext_{\mathcal{P}}^1$ of Ext^1 . This construction gives rise to a lattice structure on subsets of Ext^1 . In this talk, we will observe this lattice structure and also some natural isomorphisms with $Ext_{\mathcal{P}}^n$ that are similar to those on Ext^n . (Received October 15, 2012)

1087-18-62 **Kenneth S. Brown*** (kbrown@cornell.edu). *Rewriting systems and discrete Morse theory*.

In the 1980s Ross Geoghegan and I introduced a method for "collapsing" a CW complex to a quotient complex with fewer cells. We did this in connection with our study of the homological properties of Richard Thompson's group F . I later showed that there was a similar "collapsing scheme" that could be applied to any group presented by a complete rewriting system.

Discrete Morse theory, which was developed in the 1990s and is well known to algebraic combinatorialists, is equivalent to the theory of collapsing schemes. But the connection with rewriting systems does not seem to be as well known. In this talk I will describe collapsing schemes in their original form and survey the applications to homological group theory, with emphasis on rewriting systems. (Received November 26, 2012)

1087-18-188 **Pye Phyo Aung*** (pye.aung@ndsu.edu). *Amalgamated Duplication, Pseudo-canonical Covers and Gorenstein Homological Algebra*. Preliminary report.

When C is a semidualizing module over a commutative ring, Holm and Jørgensen studied some connections between C -Gorenstein injectivity/projectivity and Nagata's trivial extension. We generalized some of those results to other general constructions, including the amalgamated duplication of a ring along an ideal introduced by D'anna and Fontana. We also identified some key properties of those general constructions that enable their connections to Gorenstein injectivity and projectivity. (Received December 03, 2012)

22 ► *Topological groups, Lie groups*

1087-22-20 **Justin Tatch Moore*** (justin@math.cornell.edu), Department of Mathematics, Malott Hall, Cornell University, Ithaca, NY 14853-4201, and **Slawomir Solecki**. *A Boolean action of $C(M, U(1))$ without a spatial model*.

We will demonstrate that if M is an uncountable compact metric space, then there is an action of the Polish group of all continuous functions from M to $U(1)$ on a separable probability algebra which preserves the measure and yet does not admit a point realization in the sense of Mackey. This is achieved by exhibiting a strong form of ergodicity of the Boolean action known as whirliness. This is in contrast with Mackey's point realization theorem, which asserts that any measure preserving Boolean action of a locally compact second countable group on a separable probability algebra can be realized as an action on the points of the associated probability space. The proof utilizes a lemma concerning infinite dimensional Gaussian measure which may be of independent interest. This is joint work with Slawomir Solecki. (Received November 29, 2012)

1087-22-42 **Michael P Cohen*** (michaelcohen@my.unt.edu), 1600 W Oak St Apt 3, Denton, TX 76201. *Measures and two-sided translations in non-locally compact Polish groups*. Preliminary report.

We discuss the phenomenon of Haar null sets, sometimes called shy sets, which form a measure-theoretic σ -ideal, i.e. a "smallness notion," in any Polish group which is invariant under the group's action on itself by two-sided translations. If the group in question is not locally compact, then this ideal is special, because it cannot be realized as the zero-ideal of any particular σ -finite, regular Borel measure. We will describe the curious behavior

of some two-sided translations, and give some new results in Haar null sets for a large class of non-locally compact groups. For instance, we show that some groups may always be decomposed into the disjoint union of a Haar null set and a meager set. (Received November 18, 2012)

1087-22-143 **Phillip R Wesolek*** (pwesol3@uic.edu), MSCS, University of Illinois at Chicago, 322 Science and Engineering Offices (m/c 249), 851 s. Morgan Street, Chicago, IL 60607.
Conjugacy classes in locally compact, totally disconnected Polish groups.

For certain totally disconnected Polish groups the action by conjugation admits a comeagre class. For example, S_∞ (folklore) or $\text{Aut}(\mathbb{Q}, <)$ (Truss) admit such a class. On the other hand, it is easy to see any compact group cannot contain a dense conjugacy class. Kechris and Rosendal ask if a locally compact, totally disconnected Polish group can contain a comeagre conjugacy class. We answer the question in the negative and along the way prove a number of interesting structure results. (Received December 02, 2012)

26 ► *Real functions*

1087-26-77 **Pieter C Allaart*** (allaart@unt.edu), Mathematics Department, 1155 Union Circle #311430, Denton, TX 76203-5017. *The Hausdorff dimension of level sets of generalized Takagi functions.* Preliminary report.

Takagi's continuous but nowhere differentiable function is defined by

$$T(x) = \sum_{n=0}^{\infty} \frac{1}{2^n} \phi(2^n x),$$

where $\phi(x)$ is the distance from x to the nearest integer. Recently there has been a great deal of interest in the level sets of T , which have been shown to possess many surprising properties. In particular it is now known that the maximal Hausdorff (and box-counting) dimension of the level sets of T is $1/2$. This talk concerns the dimension of level sets of the more general functions of the form

$$f(x) = \sum_{n=0}^{\infty} \frac{\omega_n(x)}{2^n} \phi(2^n x),$$

where each ω_n is a $\{-1, 1\}$ -valued function which may jump only at points $k/2^n$, so that each term of the above series is a continuous function. For such functions, the dimension of the level sets can be considerably greater than $1/2$. A sharp upper bound for this dimension will be presented, but on the other hand, it will be shown that the original bound of $1/2$ remains valid in the special case when each ω_n is constant. If time permits, the case when the sign functions ω_n are chosen at random will also be discussed. (Received November 27, 2012)

30 ► *Functions of a complex variable*

1087-30-18 **Igor E Pritsker*** (igor@math.okstate.edu), Department of Mathematics, Oklahoma State University, Stillwater, OK 74078. *Expected discrepancy for zeros of random polynomials.*

We study asymptotic clustering of zeros of random polynomials on the unit circumference. The limiting distribution of zeros according to the normalized arclength measure is well known for many sequences of classical and random polynomials. We establish a quantitative result that the expected discrepancy of roots of a polynomial of degree n , with not necessarily independent coefficients, decays like $\sqrt{\log n/n}$. Our proofs rely on discrepancy estimates generalizing the Erdős-Turán theorem, and on order statistics of a random variable. We also consider the expected number of zeros lying in certain subsets of the plane, such as circles centered on the unit circumference, and polygons inscribed in the unit circumference. This is a joint work with Alan Sola (University of Cambridge). (Received November 04, 2012)

31 ► *Potential theory*

1087-31-25 **Mykhailo Bilogliadov*** (mbilogli@math.okstate.edu), Department of Mathematics, Oklahoma State University, Stillwater, OK 74078. *Equilibria of the field generated by point charges at the vertices of a regular polygon.* Preliminary report.

We consider the problem of finding the number of equilibrium points for a potential generated by n positive unit point charges placed at the vertices of a regular polygon. We prove that the equilibrium points are located on the bisectors of the sides of this polygon. (Received November 08, 2012)

1087-31-72 **Wilhelmina Wise*** (ninadawn@gmail.com), Department of Mathematics, Oklahoma State University, Stillwater, OK 74078. *Reverse Triangle Inequalities for Infimums of Potentials.*

The triangle inequality $\inf_E \sum_{j=1}^m f_j \geq \sum_{j=1}^m \inf_E f_j$ holds for any real-valued functions f_j defined on a compact set E . We can find a reverse triangle inequality $\inf_E \sum_{j=1}^m p_j \leq C + \sum_{j=1}^m \inf_E p_j$ for potentials. We give sharp constants for certain potentials and connect these to polarization inequalities. The main tool we use is a Riesz representation for the farthest distance function. This function and the properties of its Riesz representing measure are the central topic of my dissertation. (Received November 28, 2012)

1087-31-82 **J. S. Brauchart** and **D. P. Hardin*** (doug.hardin@vanderbilt.edu), Department of Mathematics, SC1326, Vanderbilt University, Nashville, TN 37072, and **E. B. Saff**. *The next-order term for optimal Riesz and logarithmic asymptotics on the sphere.*

We review known results and present estimates and conjectures for the next-order term in the asymptotics of the optimal logarithmic energy and Riesz s -energy of N points on the d -dimensional unit sphere. The conjectures are based on analytic continuation assumptions (with respect to s) for the coefficients in the asymptotic expansion (as N goes to infinity) of the optimal s -energy. (Received November 28, 2012)

1087-31-106 **Vilmos Totik*** (totik@mail.usf.edu). *Zeros of polynomials with minimal norm.*

For a smooth Jordan curve it is shown that zeros of polynomials on the curve necessarily enlarge their supremum norm compared to the extremal (Chebyshev) polynomials. A sharp quantitative estimate is given for this higher norm in terms of the equilibrium measure of the curve. (Received November 30, 2012)

1087-31-108 **Peter D. Dragnev*** (dragnevp@ipfw.edu), Department of Mathematical Sciences, IPFW, 2101 E. Coliseum Blvd., Fort Wayne, IN 46805. *Characterizing Stationary Logarithmic Points.*

The product of all $N(N-1)/2$ possible distances for a collection of N points on the circle is maximized when the points are (up to rotation) the N -th roots of unity. There is an elegant elementary proof of this fact. In higher dimensions the problem becomes much more complicated. For example, if the points are restricted to the unit sphere in 3-space, the result is known for $N = 1 - 6$, and 12. We will derive a characterization theorem for the stationary points in d -space and illustrate it with a couple of examples of optimal configurations that are new in the literature. (Received November 30, 2012)

1087-31-113 **David Benko*** (dbenko@southalabama.edu), Department of Mathematics and Statistics, University of South Alabama, ILB 325, 411 University Blvd North, Mobile, AL 36688-0002. *The real beauty of potential theory.*

We all know that potential theory is beautiful. However it is even more beautiful than one would think. Using a balayage technique we generate amazing fractal-like images and animations. For example, a unique 3D webpage can be seen at www.hwork.us. (Received December 01, 2012)

1087-31-147 **Edward B Saff***, edward.b.saff@vanderbilt.edu. *Riesz polarization on manifolds.* Preliminary report.

We derive bounds and asymptotics for the maximum Riesz polarization quantity

$$M_n^p(A) := \max_{\mathbf{x}_1, \mathbf{x}_2, \dots, \mathbf{x}_n \in A} \min_{\mathbf{x} \in A} \sum_{j=1}^n \frac{1}{|\mathbf{x} - \mathbf{x}_j|^p}$$

for quite general sets $A \subset \mathbb{R}^m$ with special focus on the unit sphere and unit ball. We also discuss the recent solution of the Ambrus, Ball and Erdelyi polarization conjecture for the unit circle. Some of the work presented is joint with T. Erdelyi, D. Hardin, and A. Kendall. (Received December 02, 2012)

32 ► *Several complex variables and analytic spaces*

1087-32-160 **Dragomir Saric*** (dragomir.saric@qc.cuny.edu), Department of Mathematics, Queens College, 65-30 Kissena Blvd., Flushing, NY 11367. *Shear coordinates and circle maps.*

We give parametrizations of several classes of circle maps in terms of shear coordinates on the Farey tessellation. Applications to Teichmüller theory will be outlined. (Received December 03, 2012)

34 ► *Ordinary differential equations*

1087-34-40 **Nadhem Echi*** (echi_fst@yahoo.fr), El Manar University Faculty of Sciences Tunis, 1000 El Manar Tunis, Tunisia, Tunisia. *Approximate solution of second-order linear differential equation*. Preliminary report.

This paper presents an efficient approach for determining the solution of second-order linear differential equation. The second-order linear ordinary differential equation is first converted to a Volterra integral equation. By solving the resulting Volterra equation by means of Taylor's expansion, different approaches based on differentiation and integration methods are employed to reduce the resulting integral equation to a system of linear equation for the unknown and its derivatives the approximate solution of second-order linear differential equation is obtained. Test example demonstrates the effectiveness of the method and gives the efficiency and high accuracy of the proposed method. (Received November 17, 2012)

35 ► *Partial differential equations*

1087-35-102 **Michael M. H. Pang*** (pangm@missouri.edu), Dept of Mathematics, University of Missouri, Columbia, MO 65211. *Some results on domain perturbations of Dirichlet and Neumann Laplacians*. Preliminary report.

Let L be the Laplace operator defined on a bounded domain D with either Dirichlet or Neumann boundary conditions. If L is defined with Dirichlet boundary conditions, then it automatically has discrete spectrum. If L is defined with Neumann boundary conditions, we will assume that L has discrete spectrum. The numerical computation of the eigenvalues and eigenfunctions of L often requires that Ω be replaced by an approximating domain with polygonal or piecewise smooth boundary. In this talk we will present some recent results on the stability of the eigenvalues and eigenfunctions of L under domain perturbations, i.e., how do the eigenvalues and eigenfunctions of L change when the domain D is perturbed. (Received November 30, 2012)

37 ► *Dynamical systems and ergodic theory*

1087-37-6 **David M McClendon*** (mcclemd2@ferris.edu), ASC 2021, Big Rapids, MI 49307. *Speedup equivalence of ergodic \mathbb{Z}^d -actions*.

In 1985 Arnoux, Ornstein and Weiss proved that given any two ergodic measure-preserving transformations, there is a speedup of one which is isomorphic to the other. Recently, Babichev, Burton and Fieldsteel gave an relative version of this result and used this result to classify finite extensions of ergodic transformations up to "speedup equivalence". This talk will discuss joint work with Aimee S.A. Johnson (Swarthmore College) in which we define an appropriate notion of "speedup" for measure-preserving actions of \mathbb{Z}^d and discuss results analogous to those described above for actions of \mathbb{Z}^d . (Received September 10, 2012)

1087-37-16 **Ming Jiang*** (mjiang2@ncsu.edu), 2108 SAS Hall, Department of Mathematics, Campus Box 8205, Raleigh, NC 27606, and **Xiao-Biao Lin**. *Travelling wave solutions, periodic and chaotic solutions in coupled Chua's Circuits*.

In this paper, we studied a singularly perturbed system of partial differential equations, which models an one-dimensional array of coupled Chua's circuits. The PDE system is a natural generalization of the FitzHugh-Nagumo's equation and exhibits more complicated behaviors. We also showed that the system can have a variety of traveling wave and periodic solutions. First asymptotic method was used in the singularly perturbed system to construct solutions in singular and regular layers. Then dynamical systems method was used to obtain the exact solutions near the approximations obtained by the formal method. Moreover, we obtained chaotic solution for this system based on a pair of heteroclinic solution by analytic method of Lyapunov-Schmidt reduction. We showed that there are infinitely many chaotic solutions, each solution uniquely corresponds to a sequence of symbols. (Received October 31, 2012)

1087-37-23 **Aimee S.A. Johnson*** (aimee@swarthmore.edu), Department of Mathematics and Statistics, Swarthmore College, Swarthmore, PA 19081, and **David M. McClendon** (DavidMcClendon@ferris.edu), Ferris State University, Big Rapids, MI 49307. *Speedups of Ergodic Group Extensions of \mathbb{Z}^d actions*.

Arnoux, Ornstein, and Weiss showed in 1985 that given any two aperiodic measure-preserving transformations (X, T) and (Y, S) , it was possible to find a measurable function $p : X \rightarrow \mathbb{N}$ such that, by setting $\bar{T}(x) = T^{p(x)}(x)$,

(X, \overline{T}) would be isomorphic to (Y, S) . In other words, one could "speed up" T to look like S . A relative version of this result dealing with ergodic group extensions was recently obtained by Babichev, Burton, and Fieldsteel.

In this talk we discuss what is meant by a *speedup* of an action of d commuting measure preserving transformations, and describe results which generalize the previous ideas to ergodic \mathbb{Z}^d actions. (Received November 08, 2012)

1087-37-28 **John T. Griesmer*** (jtgriesmer@gmail.com). *Sumsets with one dense and one infinite summand.*

We study sets of integers of the form $A+B := \{a+b : a \in A, b \in B\}$, where A is infinite and B has positive upper Banach density. We exploit a spectral property of the special measure preserving systems (nilsystems) which arise in the study of dense sets of integers, and we find that under our hypotheses, $A+B$ must contain many kinds of finite configurations which may not appear in an arbitrary dense set of integers. This investigation leads to some natural and elementary questions about sets of (single) recurrence. (Received November 09, 2012)

1087-37-31 **Nandor J Simanyi*** (simanyi@uab.edu), 1300 University Boulevard, Birmingham, AL 35294-1170. *Brief history of the Boltzmann-Sinai Ergodic Hypothesis.*

The Boltzmann-Sinai Hypothesis dates back to 1963 as Sinai's modern formulation of Ludwig Boltzmann's statistical hypothesis in physics, actually as a conjecture: Every hard ball system on a flat torus is (completely hyperbolic and) ergodic (i. e. "chaotic", by using a nowadays fashionable, but a bit profane language) after fixing the values of the obviously invariant kinetic quantities.

In the half century since its inception quite a few people have worked on this conjecture, made substantial steps in the proof, created useful concepts and technical tools, or proved the conjecture in some special cases, sometimes under natural assumptions. Quite recently I was able to complete this project by putting the last, missing piece of the puzzle to its place, getting the result in full generality.

In the talk I plan to present the brief history of the proof by sketching the most important concepts and technical tools that the proof required. (Received November 13, 2012)

1087-37-34 **Martin J Schmoll*** (schmoll@clemson.edu) and **Charles C Johnson.** *Dynamical and fractal properties of the doubly periodic wind-tree model.*

We report on a new approach to study trajectories on the wind-tree model via Panov planes. Panov planes are complex planes with singularities coming from attaching flat spheres in a double periodic pattern. Dynamics on (a certain class of) Panov planes applies to the wind-tree model. We particularly look at situations where many directions on the Panov plane are eigendirections of pseudo-Anosov maps, i.e. where the plane is a lattice surface. We report on fractal properties of the trajectories and fractal properties of the directions.

This is work in progress with Chris Johnson (Clemson) (Received November 15, 2012)

1087-37-38 **Hong-Kun Zhang*** (hongkunz@gmail.com), Dept. of Math & Stat., University of Massachusetts, Amherst, MA 01003. *Lower bound for slow decay rates of correlations.* Preliminary report.

We obtain the optimal lower bound for slow decay rates of convergence to SRB measures for nonuniformly hyperbolic systems with singularities including chaotic billiards. Our result is applied to certain billiards as well as some hyperbolic maps with singularities. This talk is based on recent joint work with Nikolai Chernov and Sandro Vaienti. (Received December 04, 2012)

1087-37-54 **Hasina Akter*** (hasina.math@gmail.com), 1401 S. US 421, SWRZ 310, Westville, IN 46391, and **Mariusz Urbanski** (urbanski@unt.edu), 1155 Union Circle #311277, Denton, TX 76203. *Real Analyticity of Hausdorff Dimension of Disconnected Julia Sets of Cubic Parabolic Polynomials* $f_\lambda(z) = z(1 - z - \lambda z^2)$.

Consider the family of cubic polynomials $f_\lambda(z) = z(1 - z - \lambda z^2)$ such that for each $\lambda \in D_0$, the parameter set, the polynomial f_λ is parabolic and one finite critical point of f_λ escapes to infinity. The concern about the family is that the members of this family are generally not even bi-Lipschitz conjugate on their Julia sets $J(f_\lambda)$. We have proved that D_0 is open and contains a deleted neighborhood of 0. Our main result is that the Hausdorff dimension function $\lambda \mapsto \text{HD}(J(f_\lambda))$ is real analytic. To prove this we have constructed a holomorphic family of holomorphic parabolic graph directed Markov systems whose limit sets coincide with the Julia sets of polynomials $\{f_\lambda\}_{\lambda \in D_0}$ up to a countable set. Then we associate to this holomorphic family of holomorphic parabolic graph directed Markov systems an analytic family, call it $\{S_\lambda\}_{\lambda \in D_0}$, of conformal graph directed Markov systems with infinite number of edges in order to reduce the problem of real analyticity of Hausdorff dimension for the given family of polynomials $\{f_\lambda\}_{\lambda \in D_0}$ to prove the corresponding statement for the family $\{S_\lambda\}_{\lambda \in D_0}$. (Received November 24, 2012)

1087-37-57 **Steve Kass** and **Kathleen Madden*** (kmadden@drew.edu), Department of Mathematics & Computer Science, Drew University, Madison, NJ 07940. *A Sufficient Condition for Non-Soficness in Higher Dimensions.*

Shift spaces are sets of infinite words of symbols (or in the case of higher dimensions, infinite arrays of symbols) that model the evolution of discrete systems. Of particular interest are the shifts of finite type; these shift spaces are defined by a finite collection of forbidden patterns, and they find multiple applications in computer science and in modeling other dynamical systems. Factors of shifts of finite type are called sofic systems, and in one dimension, sofic systems are well understood. In particular, there is a complete characterization of soficness in one-dimension. There are no such characterizations in higher dimensions. In this talk we will give a condition that implies non-soficness in higher-dimensional shift spaces, and we will apply it to a variety of examples. (Received November 25, 2012)

1087-37-78 **Su Gao*** (sgao@unt.edu), Department of Mathematics, University of North Texas, 1155 Union Circle #311430, Denton, TX 76203. *The Conjugacy Problem for Bernoulli Subshifts.*

I will speak about results on the classification of Bernoulli subshifts up to topological conjugacy. For general Bernoulli subshifts the classification problem is known to be a countable Borel equivalence relation of maximal complexity. However, the exact complexity for the corresponding problem for minimal systems is not known. I will talk about some recent results that are joint work with Clemens, Hill, Jackson, and Seward. (Received November 27, 2012)

1087-37-100 **Andrei E Ghenciu*** (eghenciu@ecok.edu), Ada, OK 74820, and **Mario Roy.** *Boundedly Supermultiplicative Shifts.* Preliminary report.

We introduce and study a class of shifts called essentially boundedly supermultiplicative. This large class contains all subshifts of finite type. We give several examples and we show how to compute the entropy for such systems. (Received November 30, 2012)

1087-37-104 **Karl Backs***, Department of Mathematics, 1155 Union Circle #311430, Denton, TX 76203-5017, and **Steve Jackson** and **R Daniel Mauldin.** *Disintegrations of σ -finite measures and Π_1^1 sets.* Preliminary report.

A disintegration of measure is a common tool used in ergodic theory, probability, and descriptive set theory. Traditionally disintegrations of measures are considered in settings where the measures of interest are finite. However in infinite ergodic theory such a luxury may not be available. In situations where the measures are σ -finite it is desirable that a disintegration of measure satisfy certain uniformity conditions. Dorothy Maharam was interested in such uniformly σ -finite disintegrations and asked whether this condition is always attained.

In this talk I will discuss recent work with R. Daniel Mauldin and Steve Jackson in which we present an answer to Maharam's question by using Gödel's axiom of constructibility, $\mathbf{V} = \mathbf{L}$, to construct a non-uniformly σ -finite disintegration of measure. Such a disintegration can also be constructed if one replaces the assumption $\mathbf{V} = \mathbf{L}$ with \mathbf{CH} , though Maharam's question remains open in \mathbf{ZFC} . (Received November 30, 2012)

1087-37-107 **Miaohua Jiang*** (jiangm@wfu.edu), PO Box 7388, Wake Forest University, Department of Mathematics, Winston Salem, NC 27109. *Entropy of the Sinai-Ruelle-Bowen Measures.* Preliminary report.

For uniformly hyperbolic maps, the quantities that characterize the global dynamics such as the entropy of the SRB invariant measure and the Hausdorff dimension of the hyperbolic set depend on the map differentiably. Their derivatives can be calculated formally as well as numerically. (Received November 30, 2012)

1087-37-115 **Bethany D Springer*** (springer@math.colostate.edu), 2824 Dundee Court, Fort Collins, CO 80525, and **Andres del Junco** (deljunco@math.utoronto.edu). *All minimal isometries of compact metric spaces are nearly continuously evenly Kakutani equivalent.* Preliminary report.

Nearly continuous, ergodic transformations T and S of compact metric spaces X and Y are said to be nearly continuously Kakutani equivalent if there exists nearly clopen subsets $A \subset X$ and $B \subset Y$ such that the induced transformations T_A and S_B are nearly continuously conjugate. In the case where $\mu(A) = \nu(B)$, the systems are said to be nearly continuously evenly Kakutani equivalent (nceKe). In a quest to understand the nature of this equivalence, Dan Rudolph modified the Hamachi-Keane machinery to establish a new kind of machinery suitable for establishing the needed conjugacy, and in the process, creating a nearly continuous orbit equivalence. Authors Dan Rudolph, Mrinal Roychowdhury, and Andrew Dykstra rely heavily upon a canonical cutting and stacking construction to prove that all adding machines are nceKe and then that all irrational rotations are nceKe, leading to questions about whether more generic systems without a canonical cutting and stacking can

be shown to be nceKe. In this presentation, we discuss a modification of the tower and template machinery in orde to show that any minimal isometry of a compact metric space is nceKe to the binary odometer, and hence, to any other minimal isometry. (Received December 01, 2012)

1087-37-116 **Mark Demers*** (mdemers@fairfield.edu) and **Hongkun Zhang** (hongkun@math.umass.edu). *Perturbations of dispersing billiards via spectral methods.*

We will discuss perturbations of the billiard map associated with a periodic Lorentz gas via the stability of the spectrum of the associated transfer operator. Recently, we constructed Banach spaces on which the transfer operator for the unperturbed billiard enjoys a spectral gap. We will present a number of perturbations which fit into this functional analytic framework and for which the spectral gap persists, including: movements and deformations of scatterers, external forces with thermostating, twists or kicks at reflections, and random perturbations composed of these various classes. This approach recovers many known results for these systems and establishes several new ones. (Received December 01, 2012)

1087-37-117 **Romain Aimino, Matthew Nicol*** (nicol@math.uh.edu) and **Sandro Vaienti**. *Limit theorems for annealed and quenched dynamics.*

Suppose we have a countable set of maps $\{T_i\}$, $i \in S$ is an index set. The maps $T_i : X \rightarrow X$ act on a metric space X which supports a probability measure m . We choose the maps independently according to a probability measure μ on S . This gives rise to a random dynamical system which may be modeled as a skew-product on $X \times S^{\mathbb{Z}}$, with skew-product map $F(x, \omega) = (T_{\omega_0}x, \sigma\omega)$ where $\omega = (\omega_0, \omega_1, \dots, \omega_n, \dots) \in S^{\mathbb{Z}}$ and σ is the shift map, $\sigma\omega = (\omega_1, \omega_2, \dots, \omega_n, \dots)$.

Annealed dynamics refers to the skew-product defined on the product space $X \times S^{\mathbb{Z}}$ according to the product measure $m \times \mu^{\mathbb{Z}}$. Quenched dynamics consists in fixing $\omega \in \Omega$ and looking at the behavior of the resulting composition of maps.

We give conditions under which an annealed transfer operator has a spectral gap on a suitable Banach space and using this to establish annealed and quenched versions of central limit theorems, large deviations results and dynamical Borel-Cantelli lemmas. Applications include settings where the chosen maps may include non-uniformly expanding and intermittent type maps. (Received December 01, 2012)

1087-37-118 **Jingyu Chen, Luke Mohr, Hong-Kun Zhang and Pengfei Zhang*** (pzhang@math.umass.edu). *A new family of convex billiard tables with ergodicity.*

We investigate numerically a new family of convex tables $Q(r, R, d)$, obtained by intersecting two circles. It is shown that the billiard map is ergodic if the distance d between two centers takes an intermediate value. Moreover phase transitions are observed with extremal distances. (Received December 01, 2012)

1087-37-119 **Vaughn Climenhaga*** (climaha@math.uh.edu) and **Yakov Pesin** (pesin@math.psu.edu). *Effective hyperbolicity and applications of new Hadamard-Perron theorems.*

The Hadamard-Perron theorem gives some control over dynamics near a hyperbolic trajectory. In the classical approach to non-uniform hyperbolicity via Pesin theory, the strength of this control is given in terms of asymptotic properties of the trajectory; these are then determined almost everywhere using ergodic theory. This renders the theory difficult to use for systems where existence of an SRB measure has not yet been established. We introduce a notion of "effective hyperbolicity" that bounds the strength of this control without recourse to ergodic theory, allowing us to prove new versions of the Hadamard-Perron theorem. Applications include construction of SRB measures and a finite-information closing lemma. (Received December 01, 2012)

1087-37-120 **Leonid Bunimovich*** (bunimovh@math.gatech.edu). *Coexistence of regular and chaotic regions without defocusing and stickiness.*

We will present examples of billiards with smooth boundary and divided phase space (into regions with regular and with chaotic dynamics), where there is no defocusing after each reflection off the boundary in chaotic region and no stickiness near the boundary(ies) of regular region(s). (Received December 01, 2012)

1087-37-121 **Danijela Damjanovic*** (dani@rice.edu). *Global hypoellipticity of leafwise Laplacian and local rigidity of some parabolic homogeneous actions.*

Unlike the case of vector fields, global hypoellipticity of a system of two or more commuting vector fields is a very weak property. However, global hypoellipticity of the leafwise Laplacian is sufficient to imply finite dimensional first and second cohomology in general, and for particular actions on 2-step nilmanifolds even trivial first cohomology. For the examples on 2-step nilmanifolds this gives transversal local rigidity for these parabolic

homogeneous actions. This is a natural extension of the classical KAM result of Arnold and Moser about perturbations of Diophantine vector fields on tori. (Received December 01, 2012)

1087-37-122 **Federico Bonetto** (bonetto@math.gatech.edu), **Nikolai Chernov*** (chernov@math.uab.edu), **Alexey Korepanov** (khu@uab.edu) and **Joel Lebowitz** (lebowitz@math.rutgers.edu). *Local characteristics of SRB measures.*

We derive Green-Kubo type formulas for the densities of the projections of Sinai-Ruelle-Bowen (SRB) measures in non-equilibrium Lorentz periodic gases. Those densities represent physically interesting quantities like “particle density”, “local electrical current”, and “angular velocity distribution”. We also prove that despite the singular nature of the SRB measure its projections on transversal subspaces are absolutely continuous. (Received December 01, 2012)

1087-37-123 **Davide Ambrosi** (davide.ambrosi@polimi.it), **Gianni Arioli** (gianni.arioli@polimi.it) and **Hans Koch*** (koch@math.utexas.edu). *A computer assisted enclosure for invariant manifolds.*

We describe a new technique for computing a tight enclosure for the stable and unstable manifolds at a stationary point of an autonomous, finite dimensional dynamical system. This method is used to prove the existence of a traveling wave for a PDE modeling the propagation of electric signals in biological tissues, and to give an accurate and rigorous estimate of the wave speed. (Received December 01, 2012)

1087-37-124 **Vladimir Dragovic*** (vladimir.dragovic@utdallas.edu) and **Milena Radnovic** (milena@mi.sanu.ac.rs). *Pseudo-integrable billiards and arithmetic dynamics.*

We introduce a class of nonconvex billiards with a boundary composed of arcs of confocal conics which contain reflex angles. We present their basic topological and arithmetic properties. We study their periodic orbits and establish a local Poincaré recurrence theorem. The connection with interval exchange transformation is established together with the Keane-type conditions for minimality. (Received December 01, 2012)

1087-37-125 **Leonid Bunimovich** (bunimovh@math.gatech.edu) and **Alexander Grigo*** (grigo@math.ou.edu). *Elliptic periodic orbits in C^2 -smooth stadium billiards.*

The stadium billiard is one of the simplest examples of hyperbolic and ergodic convex billiards. The existence of such billiards came as a great surprise, because Lazutkin showed in 1973 that strictly convex billiard tables with smooth enough boundary have caustics, hence cannot be ergodic.

When smoothing out the ends of the circular arcs of the usual stadium billiard such that the curvature of the resulting curved segment vanishes at its endpoint one obtains a C^2 -smooth stadium. We show that even for arbitrarily short smoothed out regions the resulting C^2 -stadium billiard has elliptic periodic orbits for arbitrary short and also for arbitrary large separation distances of the two curved boundary components. (Received December 01, 2012)

1087-37-126 **Konstantin Khanin** (khanin@math.utoronto.ca) and **Sasa Kocic*** (skocic@olemiss.edu). *Renormalization conjecture and rigidity theory for circle maps with breaks.*

We prove the renormalization conjecture for circle maps with a break, i.e., for circle diffeomorphisms with a single singular point where the derivative has a jump discontinuity. The theorem claims that any two $C^{2+\alpha}$ -smooth ($\alpha > 0$) circle maps with a break, with the same irrational rotation number and the same size of the break, approach each other exponentially fast (in the C^2 -topology). As a corollary, we obtain a strong rigidity statement for such maps: for almost all irrational numbers ρ , any two circle maps with a break, with the same rotation number ρ and the same size of the break, are C^1 -smoothly conjugate to each other. As we proved earlier, the latter claim cannot be extended to all irrational rotation numbers. These results can be considered an extension of Herman theory on the linearization of circle diffeomorphisms. (Received December 01, 2012)

1087-37-129 **Yaroslav Vorobets***, yvorobet@math.tamu.edu. *Totally nonfree actions of self-similar groups.*

An action of a countable group is called totally nonfree if, generically, all points have distinct stabilizers. Every group has a universal nonfree action, namely, the action on the space of its own subgroups by conjugation.

A self-similar group is a transformation group acting on a regular rooted tree in a special way so that the action reproduces itself on subtrees. The talk is concerned with one class of self-similar groups, the branch groups, for which the natural action is totally nonfree. In particular, I will describe how the natural action is related to the universal nonfree action. (Received December 02, 2012)

1087-37-130 **Rafael de la Llave** and **Nikola P. Petrov*** (npetrov@ou.edu), Department of Mathematics, University of Oklahoma, 601 Elm Avenue, Norman, OK 73019, and **Arturo Olvera**. *Heteroclinic shadowing and applications to renormalization.*

We propose certain asymptotic relations among the scaling exponents of different transitions to chaos, called the *Principle of Approximate Combination of Scaling Exponents* (PACSE). According to PACSE, if the combinatorics of a transition is a composition of two simpler combinatorics, then the scaling exponent of this transition is approximately equal to the product of the scaling exponents of the two simpler transitions. We give numerical evidence for PACSE for unimodal maps, circle maps, dynamics on the boundaries of Siegel disks, and area-preserving twist maps.

We propose an explanation of PACSE in terms of the dynamical properties of the renormalization operators. More precisely, the numerically observed phenomena would occur if the stable and unstable manifolds of two hyperbolic fixed points of the renormalization operators (corresponding to different transitions to chaos) intersect transversely. As an essential ingredient in the theoretical justification of this proposal, we prove a general shadowing theorem that works for infinite dimensional discrete dynamical systems that are not necessarily invertible (which is the case of the renormalization operators acting in appropriate function spaces). (Received December 02, 2012)

1087-37-135 **James T. Campbell*** (jcamp11@memphis.edu), 373 Dunn Hall, Dept. of Math. Sci., University of Memphis, Memphis, TN 38152, and **Jared T. Collins**. *Specifying Attracting Cycles for Newton Maps of Polynomials.*

We show that for any set of n distinct points in the complex plane, there exists a polynomial p of degree at most $n + 1$ so that the corresponding Newton map, or even the relaxed Newton map, for p has the given points as a super-attracting cycle. This improves the result in [?], which shows how to find such a polynomial of degree $2n$. Moreover we show that in general one cannot improve upon degree $n + 1$. Our methods allow us to give a simple, constructive proof of the known result that for each cycle length $n \geq 2$ and degree $d \geq 3$, there exists a polynomial of degree d whose Newton map has a super-attracting cycle of length n . (Received December 02, 2012)

1087-37-142 **Mrinal K Roychowdhury*** (roychowdhurymk@utpa.edu), 1201 West University Drive, Dept of Mathematics (UTPA), Edinburg, TX 78539. *Quantization dimension estimate of probability measures on hyperbolic recurrent sets.*

Under the strong open set condition we have determined the bounds of the lower and the upper quantization dimensions of a probability measure supported by the limit set of a recurrent hyperbolic iterated function system. Moreover, we have shown that the lower and upper bounds are related with the temperature functions of the thermodynamic formalism corresponding to the lower and upper contractive ratios of the hyperbolic maps. (Received December 02, 2012)

1087-37-144 **Anush Tserunyan*** (anush@math.ucla.edu). *Weakly wandering sets and their generalizations.*

Consider a continuous action of a countable group G on a Polish space X . A subset W of X is called weakly wandering (ww) if it has infinitely many disjoint translates. We exhibit a recurrence-type condition, which prevents the existence of nonmeager ww sets when $G = \mathbb{Z}$. This, in particular, gives a negative answer to a question of Eigen-Hajian-Nadkarni asking whether compressibility implies the existence of a locally ww complete section. The latter question was also independently answered by Ben Miller. If time permits, we will also consider generalizations of ww sets and explore their connection with compressibility and finite generators for an arbitrary countable group G . (Received December 02, 2012)

1087-37-148 **J. P. Boronski***, 221 Parker Hall, Auburn University, AL 36849. *A note on minimal sets of periods for cofrontier maps.*

In this talk we shall discuss the minimal sets of periods for self-maps of cofrontiers that are inverse limits of circles. A cofrontier is a compact and connected set that irreducibly separates the plane into exactly two components and is the boundary of each. There is a well-established interest in the behavior of dynamical systems in invariant cofrontiers. In our talk a cofrontier of special interest will be a pseudocircle, a remarkable space first constructed by R.H.Bing. It has a group of rational rotations acting on it, and allows minimal homeomorphisms that can be extended to area-preserving planar smooth diffeomorphisms, or planar smooth diffeomorphisms having the pseudocircle as an attractor (Handel). It can also occur as the boundary of a Siegel disk for a holomorphic map in the complex plane (Chéritat). However, it is not homogeneous (Fearnley, Rogers), does not contain any arcs, and it is nowhere locally connected (being hereditarily indecomposable). The pseudo-circle has an interesting

self-similarity feature: each proper connected and compact subspace of the pseudo-circle is homeomorphic to a pseudoarc, the simplest hereditarily indecomposable continuum. Our main tool will be an earlier result of the author and fixed point classes of cofrontier maps. (Received December 02, 2012)

1087-37-168 **Niketa Salvi*** (salvi@math.colostate.edu). *Nearly continuous version of the two-step coding theorem.*

In the 1970s, Rudolph showed that any measurable flow can be represented as a flow built under a function where the ceiling function takes only two values. We prove a version of this theorem in the nearly continuous category. Let X be a Polish space with a non-atomic Borel probability measure μ and let T be an ergodic measure-preserving homeomorphism on X . Let $f : X \rightarrow \mathbb{R}$ be a positive, nearly continuous measure-preserving function bounded away from 0 and ∞ . This gives rise to $\{\mathcal{U}_t\}_{t \in \mathbb{R}}$, a flow built under the ceiling function f in the nearly continuous category. We show that $\{\mathcal{U}_t\}_{t \in \mathbb{R}}$ is nearly continuously conjugate to a nearly continuous flow built under a function where the ceiling function takes any two irrationally related values. (Received December 03, 2012)

1087-37-172 **Steve Jackson*** (jackson@unt.edu), Department of Mathematics, University of North Texas, Denton, TX 76203, and **Su Gao** and **Brandon Seward**. *Some new results and methods in the theory of countable group actions.*

We introduce a new method for obtaining some results about the actions of countable groups. We connect these methods with those that had been developed previously. (Received December 03, 2012)

1087-37-184 **Su Gao** and **Aaron Hill*** (aaron.hill@unt.edu). *Rank-1 transformations with trivial centralizer.* Preliminary report.

There are several ways to define the class rank-1 transformations of a standard Lebesgue space. The most common is the constructive symbolic definition: one begins with a sequence $(q_n : n \in \mathbb{N})$ of integers greater than 1, and a sequence $(a_{n,i} : n \in \mathbb{N}, 0 < i < q_n)$ of natural numbers, and uses these sequences to construct (X, μ, σ) , where X is a closed subset of $\{0, 1\}^{\mathbb{Z}}$, μ is an atomless Borel measure on X , and σ is the shift map. Anything isomorphic to a triple (X, μ, σ) obtained in this form is called a rank-1 system.

In this talk, we'll review the construction mentioned above and show that if both $\sup\{q_n : n \in \mathbb{N}\}$ and $\sup\{a_{n,i} : n \in \mathbb{N}, 0 < i < q_n\}$ are finite, then the centralizer of σ in the group $\text{Aut}(X, \mu)$ equals $\{\sigma^k : k \in \mathbb{Z}\}$. (Received December 03, 2012)

1087-37-197 **Charles C Johnson*** (cj@clemson.edu) and **Martin J Schmoll** (schmoll@clemson.edu). *Involutive translation surfaces and associated Panov planes.* Preliminary report.

To a translation surface with an orientation-preserving affine involution we may, through a covering relation, associate multiple half-translation tori. The universal covers of these tori are half-translation surfaces homeomorphic to the plane. We call these covers *Panov planes*. In this talk we describe the construction of these Panov planes and give an example of how Panov planes may be used to study flows on infinite translation surfaces. (Received December 03, 2012)

1087-37-215 **Eduardo G Altmann** and **Carl P Dettmann*** (carl.dettmann@bris.ac.uk), School of Mathematics, University Walk, Bristol, BS4 2LB, United Kingdom, and **Orestis Georgiou**, **Rainer Klages** and **Georgie Knight**. *Escape and diffusion through small holes.*

A dynamical system may be "opened" by allowing trajectories to leak out through one or more holes (subsets of phase space). Given a distribution of initial conditions, we study the probability of remaining within the system as a function of time and the size and position of the hole(s). A chain of systems linked by their holes can also model deterministic diffusion. Recent results for escape and diffusion in one-dimensional expanding maps will be discussed, including the first expansion for the escape rate beyond linear order in hole size, an exact additivity formula for diffusion coefficients and new relations between escape, diffusion and periodic orbits. Connections will be made with particles escaping from containers with small holes: Open billiards. (Received December 04, 2012)

1087-37-235 **Cesar E. Silva*** (csilva@williams.edu), 18 Hoxsey Street, Mathematics Department, Williams College, Williamstown, MA 01267, and **Tudor Pădurariu**. *On the conservativity of $T \times T$ and $T \times T^{-1}$ for rank one transformations.* Preliminary report.

We will discuss a method for constructing rank one infinite measure-preserving transformations so that the products $T \times T$ and $T \times T^{-1}$ have different conservative properties and present several examples. (Received December 04, 2012)

1087-37-241 **Karin Reinhold*** (reinhold@albany.edu), Department of Mathematics, 1400 Washington Ave, Albany, NY 12222. *On random ergodic theorems*. Preliminary report.

We study convergence of random ergodic averages when the weights are given by random variables which are not identically distributed. (Received December 04, 2012)

1087-37-243 **Hongkun Zhang*** (hongkunuz@gmail.com), Dept. of Math & Stat., University of Massachusetts, Amherst, MA 01003. *Random billiards with microstructure*.

We consider certain random billiard systems, i.e., billiards in which collisions with the wall of the table satisfy a random reflection law. The Markov operator is derived from a second billiard system that defines the model of surface structure at a "microscopic" scale. The main results we present, which are recent joint work with Renato Feres, relate the spectral theory of the Markov operator, geometric properties of the surface microstructure, and the diffusion constant of the random billiard motion in channels. (Received December 04, 2012)

41 ► *Approximations and expansions*

1087-41-13 **Maxim L Yattselev*** (maximy@uoregon.edu). *Nuttall's theorem on algebraic S-contours*.

Given function f holomorphic at infinity, the n -th diagonal Padé approximant to f , say $[n/n]_f$, is a rational function of type (n, n) that has the highest order of contact with f at infinity. Equivalently, $[n/n]_f$ is the n -th convergent of the continued fraction representing f at infinity. Nuttall's theorem provides an asymptotic formula for $[n/n]_f$ and all n large enough in the case where f is the Cauchy integral of the reciprocal of a non-vanishing smooth weight with respect to the arcsine distribution on $[-1, 1]$. This talk discusses the extension of Nuttall's theorem to Cauchy integrals on the so-called algebraic S-contours. (Received October 23, 2012)

1087-41-67 **Erwin Miña-Díaz*** (minadiaz@olemiss.edu), Department of Mathematics, Hume Hall 305, P. O. Box 1848, University, MS 38677, and **Brian Simanek** (brian.z.simanek@vanderbilt.edu), Department of Mathematics, 1326 Stevenson Center, Nashville, TN 37240. *Spectral transforms of measures and orthogonal polynomials on regions*. Preliminary report.

We consider monic polynomials $\Phi_n(z)$ that are orthogonal with respect to a measure μ supported on the closed interior of an analytic Jordan curve L . Let $\varphi(z)$ be the canonical conformal map of the exterior of L onto the exterior of the unit circle, and let C be the logarithmic capacity of L , which is given by $L = 1/\varphi'(\infty)$. We give necessary conditions for the measure μ to have the property that the Szegő-type asymptotic formula

$$\lim_{n \rightarrow \infty} \frac{\Phi_n(z)}{C^n \varphi(z)^n} = D(z)$$

holds true on some simply-connected neighborhood of ∞ containing the curve L . We also prove that such a property is preserved when μ is perturbed by multiplication by a rational weight and the addition of finitely many point masses. (Received November 26, 2012)

1087-41-131 **Mourad E.H. Ismail, Xin Li*** (xli@math.ucf.edu) and **Mizan Rahman**. *Asymptotics Inequalities for Landau Constants*. Preliminary report.

We will discuss some sharp inequalities of high orders that are related to a complete asymptotic expansion for the Landau constants G_n , as $n \rightarrow \infty$. (Received December 02, 2012)

1087-41-146 **Sergiy V Borodachov*** (sborodachov@towson.edu), Towson University, Towson, MD, **Doug P Hardin**, Vanderbilt University, Nashville, TN, and **Edward B Saff**, Vanderbilt University, Nashville, TN. *Asymptotically d -energy minimizing sequences of configurations on d -dimensional sets*.

We obtain conditions for a sequence $\{\omega_N\}_{N \in \mathcal{N}}$ of N -point configurations on a Jordan measurable compact set A in \mathbf{R}^d under which the leading term (as $N \in \mathcal{N}$ gets large) of the Riesz d -energy of ω_N equals the leading term of the minimum N -point Riesz d -energy of A . This condition is, in particular, satisfied by any sequence of configurations on the set A of the form $\omega_N = (\sigma_N Y) \cap A$, $N \in \mathbf{N}$, where $\lim_{N \rightarrow \infty} \sigma_N = 0$ and $Y \subset \mathbf{R}^d$ is any full-rank lattice or any periodic set (a union of finitely many shifts of a full-rank lattice). The set Y can also be any infinite point set in \mathbf{R}^d with positive infimum of pairwise distances whose density $\Delta(Y; x, R)$ in a cube with center x and sidelength R converges uniformly (over $x \in \mathbf{R}^d$) to a finite and positive constant as $R \rightarrow \infty$. We also obtain sufficient conditions for sequences of point configurations on a certain class of manifolds in \mathbf{R}^p , $p > d$, to be asymptotically d -energy minimizing. (Received December 02, 2012)

1087-41-180 **Vasily Prokhorov*** (prokhoro@southalabama.edu), Department of Mathematics and Statistics, University of South Alabama, ILB 325, 411 University Blvd North, Mobile, AL. *On some compact Hankel forms*. Preliminary report.

We consider bounded, symmetric, bilinear forms $[x, y]$ for Hardy and Bergman spaces associated to planar domains constructed for sets minimal capacity. Properties of the forms $[x, y]$, the Hankel operators with Markov functions as symbols, and the Friedrichs operators for the corresponding planar domains will be discussed. (Received December 03, 2012)

1087-41-246 **Plamen Simeonov*** (simeonovp@uhd.edu), UHD, CMS, Suite 705 S, One Main Street, Houston, TX 77002, and **Ron Goldman** (rng@rice.edu), Houston, TX 77005. *Generalized Quantum B-Splines*. Preliminary report.

Generalized quantum splines are piecewise polynomials whose finite differences or generalized quantum derivatives agree up to some order at the joins. Just like classical and quantum splines, generalized quantum splines admit a canonical basis with compact support: the generalized quantum B-splines. We study generalized quantum B-spline bases and generalized quantum B-spline curves, using a very general variant of the blossom: the generalized quantum blossom. Applying the generalized quantum blossom, we develop algorithms and identities for generalized quantum B-spline bases and generalized quantum B-spline curves, including generalized quantum variants of the de Boor algorithms for recursive evaluation and generalized quantum differentiation, knot insertion procedures for converting from generalized quantum B-spline to piecewise generalized quantum Bezier form, and a generalized quantum variant of Marsden's identity. (Received December 05, 2012)

42 ► *Fourier analysis*

1087-42-55 **Oleksandr (Alexander) V Tovstolis*** (atovstolis@math.okstate.edu), Department of Mathematics, Oklahoma State University, 401 Mathematical Sciences, Stillwater, OK 74078. *Fourier Multipliers in Hardy Spaces and Some Inequalities of Approximation Theory*.

Let $\mathcal{M}_{p,q}(T_\Gamma)$ denotes the class of Fourier multipliers from $H^p(T_\Gamma)$ to $H^q(T_\Gamma)$, $0 < p \leq q \leq 1$, in tubes over a regular cone $\Gamma \subset \mathbb{R}^n$ (i.e., the dual cone, Γ^* , has non-empty interior).

Several conditions for multipliers are obtained. They could be successfully applied to problems of Approximation Theory. For example, the critical index for Bochner-Riesz means was found.

If a function belonging to H^p is also an entire function of exponential type, then the following Bernstein-type inequality holds true.

Theorem 1. *Let $p \in (0, \infty)$, and K be a symmetric body in \mathbb{R}^n . Then, for $f \in \mathcal{E}(K^*) \cap H^p(T_\Gamma)$ and a multi-index $k = (k_1, \dots, k_n)$,*

$$\left\| \frac{\partial^{|k|} f}{\partial z_1^{k_1} \dots \partial z_n^{k_n}} \right\|_{H^p} \leq (2\pi)^{|k|} \prod_{j=1}^n \sigma_j^{k_j} \|f\|_{H^p},$$

where $\sigma_j := \max_{t \in K \cap \Gamma^*} |t_j|$, $|k| = k_1 + \dots + k_n$.

Some Nikolskii's type inequalities are also obtained. (Received November 24, 2012)

1087-42-110 **Brian Simanek*** (brian.z.simanek@vanderbilt.edu), Department of Mathematics, 1326 Stevenson Center, Vanderbilt University, Nashville, TN 37240. *The Bergman Shift Operator on Weighted Spaces*.

Given a measure on a compact subset of the complex plane, let P be the closure of the span of the polynomials in the Hilbert space of square integrable functions with respect to this measure. The Bergman shift operator is the map of multiplication by variable, and maps P to itself. The matrix representation of this operator restricted to P takes the form of a Hessenberg matrix when one uses the basis for P consisting of the orthonormal polynomials. One is interested in describing this operator, especially by studying the limiting behavior of the matrix elements along the diagonals. We will discuss this phenomenon in several settings including the case when the measure is supported on an analytic region and the case when the measure is supported on a polynomial lemniscate. Some examples will also be discussed. (Received November 30, 2012)

46 ► Functional analysis

1087-46-9 **Joe Diestel*** (j_diestel@hotmail.com), Math Department, Kent State University, Kent, OH 44242, and **Z Riel**. *Operators that act between the Lebesgue Banach spaces over a probability, for all Banach p 's*. Preliminary report.

What can be said about a linear map that takes the non-reflexive Lebesgue spaces into themselves. This is a typical question entertained in this discussion. Among the classes studied are the representable operators, weakly compact operators, the compact operators, the completely continuous operators; also the integral and absolutely summing operators. (Received October 08, 2012)

1087-46-24 **Vladimir Troitsky*** (troitsky@ualberta.ca). *Tensor products of concavifications of Banach and vector lattices*. Preliminary report.

Let E be an Archimedean vector lattice or a Banach lattice. We consider the Fremlin projective tensor product of E with itself. The members of the order ideal generated by elements of form $x \otimes y$ where $x \perp y$ are viewed as off-diagonal. The quotient of the tensor square with respect to this ideal can be viewed as the diagonal of the tensor square. We show that this diagonal can be identified with the 2-concavification of E . Furthermore, we extend this result to the tensor product of several concavifications of E : we show that the diagonal of such a product is again a concavification of E . The talk is based on joint projects with Q.Bu, G.Buskes, A.Popov, and A.Tcaciuc and with O.Zabeti. (Received November 08, 2012)

1087-46-33 **William B. Johnson** (johnson@math.tamu.edu) and **Sofia Ortega Castillo*** (ortega@math.tamu.edu). *The cluster value problem in spaces of continuous functions*. Preliminary report.

We study the cluster value problem for certain Banach algebras of holomorphic functions defined on the unit ball of a complex Banach space X . The main results are for spaces of the form $X = C(K)$. (Received November 15, 2012)

1087-46-43 **Zhongrui shi*** (zshi@shu.edu.cn), 99 Shangda RD, Department of Mathematics, Shanghai University, Shanghai, 2000444, Peoples Rep of China. *Noncreasy and uniformly noncreasy Orlicz-Bochner function spaces*.

We point out that uniformly noncreasy is a supper-property in Banach space. And we prove that Orlicz-Bochner function spaces are noncreasy if and only if they are rotund or smooth. Finally, we obtained that Orlicz-Bochner function spaces are uniformly noncreasy if and only if they are uniformly rotund or uniformly smooth. (Received November 18, 2012)

1087-46-45 **Anton R Schep*** (schep@math.sc.edu), Dept. of Mathematics, University of South Carolina, Columbia, SC 29208. *Cone isomorphisms and almost surjective operators*.

Let E be a Banach lattice and F a Banach space. A bounded linear operator $T : E \rightarrow F$ is an isomorphism on the positive cone of E if and only if T^* is almost surjective. A dual version of this theorem holds also. A bounded linear operator $T : F \rightarrow E$ is almost surjective if and only if T^* is an isomorphism on the positive cone of F^* . Special attention will be given to positive cone isometries defined on L^p -spaces. (Received November 19, 2012)

1087-46-46 **Uri Bader**, Haifa, Israel, **Christian Rosendal*** (rosendal.math@gmail.com), Mathematics, Statistics and Computer Science, 851 S. Morgan St., University of Illinois at Chicago, Chicago, IL 60607, and **Roman Sauer**, Karlsruhe, Germany. *On the cohomology of weakly almost periodic group representations*.

The cohomology of unitary group representations is a well developed field with many applications in geometric group theory through, e.g., properties (T) and (FH). Recently, there have been attempts at developing the theory further to representations on more general Banach spaces such as uniformly convex spaces. We shall present some techniques for the study of the cohomology of weakly almost periodic representations and apply these to the vanishing of reduced cohomology. (Received November 20, 2012)

1087-46-61 **T Oikhberg*** (oikhberg@illinois.edu), Department of Mathematics, University of Illinois, Urbana, IL 61801, and **E Spinu** (spinu@ualberta.ca), Dept Of Mathematical & Statistical Sciences, University of Alberta, Edmonton, Alberta T6G 2G1, Canada. *Ideals of operators on non-commutative function spaces*.

Suppose X and Y are Banach spaces, and \mathcal{I}, \mathcal{J} are operator ideals (for instance, the ideals of strictly singular, weakly compact, or compact operators). Under what conditions does the inclusion $\mathcal{I}(X, Y) \subset \mathcal{J}(X, Y)$, or the equality $\mathcal{I}(X, Y) = \mathcal{J}(X, Y)$, hold? We examine this question when X and Y are non-commutative function

spaces. Since such spaces are ordered, we also address the same questions for positive parts of such ideals. Here is a sample result: Suppose X is either the Schatten space \mathfrak{C}_p ($1 \leq p < \infty$), or $L_p(\tau)$, where $1 < p < \infty$, and τ is a normal faithful finite trace on a hyperfinite von Neumann algebra. Then, for $T \in B(X)$, the following statements are equivalent: (i) T is not strictly singular; (ii) T is not inessential; (iii) X contains a subspace E , isomorphic to either ℓ_2 or ℓ_p , so that $T|_E$ is an isomorphism, and both E and $T(E)$ are complemented in X . For $1 < p < \infty$, these conditions are equivalent to T being strictly cosingular. (Received November 26, 2012)

1087-46-63 **Bentuo Zheng*** (bzheng@memphis.edu), Department of Mathematical Sciences, University of Memphis, Memphis, TN 38152. *Commutators on $(\sum \ell_q)_{c_0}$ and $(\sum \ell_q)_{\ell_1}$.*

Let T be a bounded linear operator on $X = (\sum \ell_q)_{c_0}$ or $(\sum \ell_q)_{\ell_1}$ with $1 \leq q < \infty$. T is said to be X -strictly singular if the restriction of T on any subspace of X that is isomorphic to X is not an isomorphism. It is shown that the unique proper maximal ideal in $\mathcal{L}(X)$ is the set of all X -strictly singular operators. With some more efforts, we prove that T is a commutator in $\mathcal{L}(X)$ if and only if for all non zero $\lambda \in \mathbb{C}$, the operator $T - \lambda I$ is not X -strictly singular. (Received November 26, 2012)

1087-46-81 **Thomas Tonev*** (tonevtv@msso.umt.edu), Mathematics Department, The University of Montana, Missoula, MT 59812. *Spectral conditions for almost composition operators between function algebras.*

Let $T : A \rightarrow B$ be a surjection between function algebras on X and Y with Choquet boundaries δA , δB . If $\|TfTg\| = \|fg\|$ and the peripheral spectrum $\sigma_\pi(TfTg)$ is in an $\varepsilon \|fg\|$ -neighborhood of $\sigma_\pi(fg)$, $f \in A$, $g \in A$, $\|g\| = 1$, where $0 \leq \varepsilon < 2/3$, then T is an almost weighted composition operator, i.e. there is a continuous $\alpha : \delta B \rightarrow \{\pm 1\}$ and a homeomorphism $\psi : \delta B \rightarrow \delta A$ so that $|(Tf)(y) - \alpha(y)f(\psi(y))| \leq 2\varepsilon |f(\psi(y))|$, $f \in A$, $y \in \delta B$. If, instead, there are $0 \leq \varepsilon < 1$, and $0 \leq \eta < 1$, with $d(\sigma_\pi(TfTg), \sigma_\pi(fg)) \leq \varepsilon \|fg\|$, and $\sigma_\pi(Tf)$ is in an η -neighborhood of $\sigma_\pi(f)$, $f \in A$, $g \in A$, $\|g\| = 1$, then T is an almost composition operator, i.e. $|(Tf)(y) - f(\psi(y))| \leq (\varepsilon + \eta) |f(\psi(y))|$, $y \in \delta B$, $f \in A$. If $\sigma_\pi(TfTg) \subset \sigma_\pi(fg)$ and $d(\sigma_\pi(Tg), \sigma_\pi(g)) \leq \eta < 1$, $f \in A$, $g \in A$, $\|g\| = 1$, then T is a composition operator, i.e. $(Tf)(y) = f(\psi(y))$, $f \in A$, $y \in \delta B$. Hence T is an algebra isomorphism. (Received November 28, 2012)

1087-46-83 **Mikhail I. Ostrovskii*** (ostrovsm@stjohns.edu), Department of Mathematics and Computer Sci, 8000 Utopia Parkway, St. John's Univeristy, Jamaica, NY 11439. *On metric characterizations of the Radon-Nikodým property (RNP) of Banach spaces (BS).* Preliminary report.

In the recent work on metric embeddings a substantial role is played by existence and non-existence of bilipschitz embeddings of metric spaces into BS with RNP (Cheeger, Kleiner, Lee, Naor, 2006–2009). William B. Johnson suggested the problem of metric characterization of RNP (August 2009). This problem can be understood in several different ways, our approach is based on the definition: A metric space X is a *test space* for RNP if the bilipschitz embeddability of X into a BS Y is equivalent to $Y \notin \text{RNP}$. It is an open problem: Does there exist a test space for the RNP? In one of our results we find a class of metric spaces X whose bilipschitz embeddability into Y implies $Y \notin \text{RNP}$, without using Cheeger's (1999) theory of metric differentiation. This class contains the infinite diamond and both Laakso (2000) spaces. We show, however, that none of the spaces X of this class is a test space for RNP: for each such X there exists a BS $Y \notin \text{RNP}$ which does not admit a bilipschitz embedding of X . We also show that a dual BS Y admits a bilipschitz embedding of an infinite diamond if and only if $Y \notin \text{RNP}$. (Received November 28, 2012)

1087-46-92 **Anna Kamińska*** (kaminska@memphis.edu), University of Memphis, Department of Mathematical Sciences, Memphis, TN 38152, and **Yves Raynaud** (yves.raynaud@upmc.fr), Université Paris 06-UPMC and CNRS, Institut de Mathématiques de Jussieu, 4 place Jussieu, F-75252 Paris, France. *New formulas for decreasing rearrangements and a class of Orlicz-Lorentz spaces.*

We present new formulas for decreasing rearrangements of functions and sequences in the spirit of Hardy and Littlewood in the context of convex functions. We use these formulas for deducing several properties of the modular functionals defining the spaces $M_{\varphi,w}$ introduced earlier in the paper [On the dual of Orlicz-Lorentz space, Proc. Amer. Math. Soc. **130** (2002), no. 6, 1645–1654, by H. Hudzik, A. Kamińska and Mastyló], for describing the Köthe dual of ordinary Orlicz-Lorentz spaces in a large variety of cases (φ is an Orlicz function and w a decreasing weight). We study these $M_{\varphi,w}$ classes in the most general setting, where they may not be even linear, and identify their Köthe duals with ordinary (Banach) Orlicz-Lorentz spaces. We introduce a new class of rearrangement invariant Banach spaces which proves to be the Köthe biduals of the preceding $M_{\varphi,w}$ classes. (Received November 29, 2012)

1087-46-97 **Edward Odell*** (odell@math.utexas.edu). *On Spreading Sequences and Asymptotic Structures*. Preliminary report.

This is joint current work with D. Freeman, B. Sari and B. Zheng. We consider the structure of conditional spreading models of a Banach space and the relationship between the spreading model structure, the asymptotic model structure and the asymptotic structure of a Banach space. (Received November 30, 2012)

1087-46-101 **Greg Knese*** (geknese@bama.ua.edu), University of Alabama, Department of Mathematics, Box 870350, Tuscaloosa, AL 35487-0350, and **Jeffrey S Geronimo** and **Plamen Iliev**. *Polynomials with no zeros on a face of the bidisk*. Preliminary report.

The classical Fejér-Riesz lemma says that a positive trigonometric polynomial can be factored as the squared modulus of a stable polynomial (i.e. a polynomial with no zeros in the closed unit disk). This lemma does not generalize in a straightforward way to two variables. Generalizing work in two variables of Geronimo and Woerdeman, Geronimo and Iliev recently gave a characterization of when such a factorization is possible in two variables where we require the trig polynomial to be the squared modulus of a polynomial that is nonvanishing on $\mathbb{T} \times \overline{\mathbb{D}}$ (a face of the bidisk). We present new refinements of this work which employ techniques from orthogonal polynomials, operator theory, and Hilbert space geometry. An interesting sums of squares formula is a corollary. (Received November 30, 2012)

1087-46-114 **Alexey Popov** and **Adi Tcaciuc*** (atcaciuc@ualberta.ca). *Every operator has almost-invariant subspaces*.

We show that any bounded operator T on a separable, reflexive, infinite dimensional Banach space X admits a rank one perturbation which has an invariant subspace of infinite dimension and codimension. In the non-reflexive spaces, we show that the same is true for operators which have non-eigenvalues in the boundary of their spectrum. In the Hilbert space, our methods produce perturbations that are also small in norm, improving on an old result of Brown and Pearcy. (Received December 01, 2012)

1087-46-132 **Lajos Molnar*** (molnarl@science.unideb.hu), Egyetem ter 1, Debrecen, H-4032, Hungary. *Isometries of some nonlinear spaces of operators*.

We investigate the structure of isometries on various nonlinear spaces of operators. We show that if the unitary groups of two unital C^* -algebras are isometric merely as metric spaces, then the underlying C^* -algebras are isometrically isomorphic as Jordan $*$ -algebras. We present a result of similar kind relating to the cones of all invertible positive elements equipped with the Thompson part metric (which is also known as the geodesic distance corresponding to a natural Finsler geometrical structure given on those cones). Finally we consider the space of all rank- n projections on a Hilbert space (our view of a Grassmann space) equipped with the gap metric, the metric coming from the operator norm. We show that in the infinite dimensional case every surjective isometry of this space of operators is implemented by either a unitary or an antiunitary operator on the underlying Hilbert space and hence the isometry can be extended to a $*$ -automorphism or to a $*$ -antiautomorphism of the full operator algebra. In particular, if $n = 1$ then the result reduces to Wigner's famous theorem on the structure of quantum mechanical symmetries.

The presented material covers joint works with Osamu Hatori, Fernanda Botelho and James Jamison. (Received December 02, 2012)

1087-46-137 **Coenraad C. A. Labuschagne*** (coenraad.labuschagne@wits.ac.za), School of Applied Mathematics, University of the Witwatersrand, Johannesburg, Gauteng 2050 WITS, South Africa. *Order and metric properties of copulas*. Preliminary report.

Copulas have applications in numerous areas of mathematics, which include probability theory, statistics, financial mathematics and many others. We discuss order and metric properties of these objects. (Received December 02, 2012)

1087-46-149 **Wei-Kai Lai*** (laiw@mailbox.sc.edu), 807 Hampton St., Walterboro, SC 29488. *A Rearrangement Inequality on Projective and Injective Tensor Products*. Preliminary report.

In 1934, Hardy, Littlewood and Polya introduced a rearrangement inequality:

$$\sum_{i=1}^m a_i b_{(m+1-i)} \leq \sum_{i=1}^m a_i b_{\sigma(i)} \leq \sum_{i=1}^m a_i b_i,$$

in which the real number sequences $(a_i)_i$ and $(b_i)_i$ are in increasing order, and $\sigma(i)$ indicates a random permutation. If instead, we use a sequence in ℓ_p , still denoted $(a_i)_i$, and a sequence in a Banach lattice X , denoted $(b_i)_i$, with a technique introduced by Bu and Buskes in 2006 we can show that in Wittstock injective tensor product,

$\ell_p \tilde{\otimes}_i X$, and Fremlin projective tensor product, $\ell_p \hat{\otimes}_F X$, the rearrangement inequality still exists. (Received December 02, 2012)

1087-46-156 **Malgorzata M Czerwinska*** (m.czerwinska@unf.edu), Department of Mathematics and Statistics, Building 14E, 1 UNF Drive, Jacksonville, FL 32224, and **Anna Kaminska**.
k-EXTREME POINTS IN SYMMETRIC SPACES OF MEASURABLE OPERATORS.

Let \mathcal{M} be a semifinite von Neumann algebra with a faithful, normal, semifinite trace τ , and E be a symmetric Banach function space on $[0, \tau(\mathbf{1}))$. The symmetric spaces $E(\mathcal{M}, \tau)$ of τ -measurable operators consists of all τ -measurable operators x for which the singular value function $\mu(x)$ belongs to E and is equipped with the norm $\|x\|_{E(\mathcal{M}, \tau)} = \|\mu(x)\|_E$.

Let $(X, \|\cdot\|)$ be a Banach space, with the unit sphere and the unit ball denoted by S_X and B_X , respectively. A point $x \in S_X$ is called k -extreme point of the unit ball B_X if x cannot be represented as an average of $k+1$ linearly independent elements from the unit sphere S_X .

We will discuss the relationships between k -extreme points of the unit ball of a symmetric function space E , and of the unit ball of the space of τ -measurable operators $E(\mathcal{M}, \tau)$.

This work was motivated by earlier results on extreme, exposed and smooth points and (local) uniform rotundity in C_E and $E(\mathcal{M}, \tau)$ by Arazy and Chilin, Krygin and Sukochev. It is a joint work with Anna Kamińska from the University of Memphis. (Received December 03, 2012)

1087-46-173 **Daniel Freeman*** (dfreema7@slu.edu), **Edward Odell** (odell@math.utexas.edu), **Bunyamin Sari** (bunyamin@unt.edu) and **Thomas Schlumprecht** (schlump@math.tamu.edu). *Equilateral sets in uniformly smooth Banach spaces.*

Let X be an infinite dimensional uniformly smooth Banach space. We prove that X contains an infinite equilateral set. That is, there exists a constant $\lambda > 0$ and an infinite sequence $(x_i)_{i=1}^\infty \subset X$ such that $\|x_i - x_j\| = \lambda$ for all $i \neq j$. (Received December 03, 2012)

1087-46-185 **Waleed K. Al-Rawashdeh*** (walrawashdeh@mtech.edu), Montana Tech, 1300 West Park Street, Butte, MT 59701. *Composition Operators between Weighted Bergman and S^p Spaces.*

Let φ be an analytic self-map of open unit disk \mathbb{D} . The operator given by $(C_\varphi f)(z) = f(\varphi(z))$, for $z \in \mathbb{D}$ and f analytic on \mathbb{D} is called composition operator. For each $p \geq 1$, let S^p be the space of analytic functions on \mathbb{D} whose derivatives belong to the Hardy space H^p . For $\alpha > -1$ and $p > 0$ the weighted Bergman space A_α^p consists of all analytic functions in $L^p(\mathbb{D}, dA_\alpha)$, where $dA_\alpha(z) = \frac{(1+\alpha)}{\pi} (1 - |z|^2)^\alpha dA(z)$ is the normalized weighted area measure.

In this talk, we characterize boundedness and compactness of composition operators act between weighted Bergman A_α^p and S^q spaces, $1 \leq p, q < \infty$. Moreover, we give a lower bound for the essential norm of composition operator from A_α^p into S^q spaces, $1 \leq p \leq q$. (Received December 03, 2012)

1087-46-194 **Chris Lennard*** (lennard@pitt.edu), Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260, and **Veysel Nezir**, Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260. *Reflexivity is equivalent to a perturbed asymptotically nonexpansive fixed point property in Banach lattices.*

Using a theorem of Domínguez Benavides and the Strong James Distortion Theorems, we prove that if a Banach space is a Banach lattice or has an unconditional basis, then it is reflexive if and only if it has an equivalent norm that has the fixed point property for cascading nonexpansive mappings. This new class of mappings strictly includes nonexpansive mappings. (Received December 03, 2012)

1087-46-207 **Damian Kubiak*** (dkubiak@tntech.edu), Mathematics Department, Tennessee Technological University, 110 University Drive; Box 5054, Cookeville, TN 38505. *Uniformly non-square points in Banach spaces and some geometric properties of Cesàro function spaces.*

We show connections between uniformly non-square points and diameter 2 properties in Banach spaces. We apply these results to Cesàro function space $C_{p,w}$, $1 < p < \infty$, induced by arbitrary positive weight function w on interval $(0, l)$ where $0 < l \leq \infty$. We prove, among others, that all non-empty relatively weakly open sets in the unit ball of $C_{p,w}$ have diameter 2. (Received December 04, 2012)

1087-46-208 **V. Mykhaylyuk, M. Popov** and **B. Randrianantoanina***, randrib@muohio.edu, and **G. Schechtman**. *Narrow and ℓ_2 -strictly singular operators from L_p* .

Let X be a Banach space. A linear operator $T : L_p \rightarrow X$ is called narrow if for each $\varepsilon > 0$ and each measurable set $A \subseteq [0, 1]$ there exists $x \in L_p$ with $x^2 = \mathbf{1}_A$, $\int_{[0,1]} x d\mu = 0$, so that $\|Tx\| < \varepsilon$. It is easy to see that compact operators are narrow, however, in general, the class of narrow operators is much larger than that of compact operators.

We prove that for $2 < p, r < \infty$ every operator $T : L_p \rightarrow \ell_r$ is narrow; and that every ℓ_2 -strictly singular operator from L_p , $1 < p < \infty$, to any Banach space with an unconditional basis, is narrow, which partially answers a question of Plichko and Popov posed in 1990.

H.P. Rosenthal proved that an operator T on $L_1[0, 1]$ is narrow if and only if for each measurable set $A \subseteq [0, 1]$ the restriction $T|_{L_1(A)}$ is not an isomorphic embedding. Inspired by this result, we find a sufficient condition, of a different flavor than being ℓ_2 -strictly singular, for operators on $L_p[0, 1]$, $1 < p < 2$, to be narrow. We define a notion of a “gentle” growth of a function and prove that for $1 < p < 2$ each operator T on L_p which, for any $A \subseteq [0, 1]$, sends a function of “gentle” growth supported on A to a function of arbitrarily small norm is narrow. (Received December 04, 2012)

1087-46-214 **Patrick N Dowling***, Department of Mathematics, Miami University, Oxford, OH 45056, and **Douglas Mupasiri**, Department of Mathematics, University of Northern Iowa, Cedar Falls, IA 50614. *A Grothendieck Compactness Principle for the Mackey Dual Topology*. Preliminary report.

Grothendieck proved that every norm compact subset of a Banach space is contained in the closed convex hull of a norm null sequence. In a recent paper of Dowling, Freeman, Lennard, Odell, Randrianantoanina and Turett, an analogous result for weak compactness in a Banach space is shown to be equivalent to the Schur property. We will consider a similar compactness principle in the Mackey dual topology of a Banach space. (Received December 04, 2012)

1087-46-245 **Dana D Clahane*** (dclahane@math.uci.edu). *Fractal membranes and weighted composition operators*. Preliminary report.

M. Lapidus and R. Nest have proposed the notion of a fractal membrane as an “adelic” product of a sequence of intervals with given lengths (or domains in some Euclidean space with the given positive real number lengths) endowed with some Hilbert space of functions, such as L^p of each interval in the product, and a suitably chosen operator that is a sum of operators on the factor Hilbert spaces in a restricted tensor product of these Hilbert spaces. Each of these operators B_j on the Hilbert space, say $L^2(I_j)$, is taken to be some variant of the square root of the Laplacian with Neumann boundary conditions on I_j . We will study the situation in which the operators B_j are replaced by another operator, in this case, $\log W_{\psi_j, \phi_j}$, where ϕ_j is a suitably regular self-map of the j th domain or interval, ψ_j is a similarly nice function on that domain for each counting number j , and W_{ψ_j, ϕ_j} is the weighted composition operator viewed as acting on the j th Hilbert space factor in the restricted tensor product, and defined by $W_{\psi_j, \phi_j}(f) = \psi_j(f \circ \phi_j)$. We will compare properties of the spectral partition function in this situation to the situation where the Laplacian square root operators are used. (Received December 04, 2012)

47 ► Operator theory

1087-47-5 **George A Anastassiou*** (ganastss@memphis.edu), Department of Mathematical Sciences, University of Memphis, Memphis, TN 38152. *Integral Operator Inequalities on Time Scales*. Preliminary report.

Here we present a wide range integral operator general inequalities on time scales under convexity. Our treatment is combined by using the diamond-alpha integral. When that fails in the fractional setting we use the delta and nabla integrals. We give plenty of interesting applications. (Received September 06, 2012)

1087-47-65 **P Lin*** (pklin@memphis.edu), Department of Mathematics, University of Memphis, Memphis, TN 38152. *Fixed point theory and nonexpansive mappings*.

We discuss the recent results of the fixed point theorem of nonexpansive mapping and provide some open questions. (Arab Math (2012) 495-509 open access at Springerlink.com) (Received November 26, 2012)

1087-47-164 **Detelin T Dosev*** (dosev@okstate.edu), Oklahoma State University, Department of Mathematics, Stillwater, OK 74075. *On a class of operators on $C(K)$* .

We consider certain classes of operators on $C(K)$ (including $C(K)$ -strictly singular operators and sums of order homomorphism) and show that all operators in these classes are commutators. To define some of these classes

we use a theorem of Kalton for representation of a Borel measure on a compact space. This work is part of the ongoing effort to classify the commutators on the Banach spaces which have Pełczyński decomposition. (Received December 03, 2012)

1087-47-204 **Gleb Sirotkin*** (sirotkin@math.niu.edu), DeKalb, IL 60115. *On a new singularity concept for operators.* Preliminary report.

In this talk we will discuss a new singularity concept for operators between Banach spaces. (Received December 04, 2012)

1087-47-220 **Jessica E. Stovall*** (jstovall@una.edu) and **William A. Feldman** (wfeldman@uark.edu). *A Decomposition for a Class of Nonlinear Functionals.*

Any Dedekind complete Banach lattice E with a quasi-interior point e is lattice isomorphic to a space of continuous, extended real-valued functions defined on a compact Hausdorff space X . Orthogonally additive, continuous, monotonic, and subhomogeneous nonlinear functionals on E are analyzed in this talk. Though these maps are not linear, a complete measure related to a nonlinear operator T is constructed and thus an associated linear map L is found. It is established that the operator T can be decomposed into the composition of two operators $L \circ S$, where S is disjointness preserving and L is linear. (Received December 04, 2012)

1087-47-226 **Alexey I. Popov*** (a4popov@uwaterloo.ca), Pure Mathematics, University of Waterloo, 200 University Avenue West, Waterloo, ON N2L 3G1, Canada. *Commutators of small rank and reducibility of operator semigroups.*

It is easy to see that if G is a group of unitary matrices, then the condition that the rank of $AB-BA$ is at most one for all A and B in G implies that G is abelian. For semigroups of operators on Banach spaces, the corresponding problem is more difficult and was a subject of study of a series of papers culminating in a work of Drnovsek who showed that every non-abelian operator semigroup satisfying this condition is reducible (that is, has a common invariant subspace). We examine the consequences of the assumption that the rank of $AB-BA$ is at most two for all operators in the semigroup S . Our conclusion is that under obviously necessary, but trivial, size conditions, S is reducible. This is a joint work with A.Jafarian, M.Radjabalipour and H.Radjavi. (Received December 04, 2012)

51 ► Geometry

1087-51-193 **Hung Lu*** (hlu@hpu.edu), 1188 fort Street Mall, Honolulu, HI 96813, and **Michel L. Lapidus** and **Machiel van Frankenhuijsen**. *Real and p -Adic Fractal Strings and Their Complex Dimensions.*

We give an overview of the theory of complex dimensions for real fractal strings. Then we present a geometric aspect of p -adic fractal strings and their complex dimensions. We obtain an explicit volume formula for the tubular neighborhood of a p -adic fractal string \mathcal{L}_p , expressed in terms of the underlying complex dimensions. We also prove that the abscissa of convergence of the geometric zeta function associated to a p -adic fractal string \mathcal{L}_p coincides with the Minkowski dimension of \mathcal{L}_p . The general theory is illustrated by some simple examples, the nonarchimedean Cantor, Euler, and Fibonacci strings.

(Received December 03, 2012)

55 ► Algebraic topology

1087-55-234 **Tulsi Srinivasan*** (tsrinivasan@uf1.edu), Department of Mathematics, University of Florida, 358 Little Hall, Gainesville, FL 32611-8105. *On the Lusternik-Schnirelmann category of Peano continua.*

We extend the definition of the Lusternik-Schnirelmann category to Peano continua, and apply the new definition to prove analogues of Whitehead's Theorem and Dranishnikov's Theorem for these spaces. We use these results to calculate the LS-category for some fractal spaces like the Sierpinski carpet, the Menger spaces, and Pontryagin surfaces. (Received December 04, 2012)

58 ► *Global analysis, analysis on manifolds*

1087-58-171 **Krystyna Kuperberg*** (kuperkm@auburn.edu), 221 Parker Hall, Mathematics, Auburn University, Auburn, AL 36849. *Box counting dimension of minimal sets in PL 1-foliations.*

In [1], the authors give examples of aperiodic piece-wise linear 1-foliations on the three-dimensional sphere, thus giving counterexamples to the Seifert conjecture in the PL category. These flows have only one minimal set, whose topological dimension can equal one or two. We will show a method of estimating the box-counting dimension of these minimal sets.

[1] G. Kuperberg and K. Kuperberg, Generalized counterexamples to the Seifert conjecture, *Annals of Mathematics* 144(1996), 239-268. (Received December 03, 2012)

60 ► *Probability theory and stochastic processes*

1087-60-50 **Kursad Tosun*** (ktosun@siu.edu). *Qualitative Analysis of Stochastic SIR Model with Disease Deaths.*

We discuss existence, uniqueness, and invariance property of solutions and stochastic asymptotic stability of disease free and endemic equilibria. (Received November 22, 2012)

1087-60-151 **James Keesling*** (kees@uf1.edu), Department of Mathematics, University of Florida, P.O. Box 118105, Gainesville, FL 32611-8105, and **Jo Ann Lee** (joann5@uf1.edu), Department of Mathematics, P.O. Box 118105, University of Florida, Gainesville, FL 32611-8105. *Estimating Fractal Dimension Using the Ripley k -Function.* Preliminary report.

The Ripley k -function is used to study the distribution of random points in a planar area or in three space. If the points are distributed by a Poisson process, then they tend to cluster around a line. The formal function is given by

$$K_n(h) = \sqrt[n]{\sum_{i=1}^m \sum_{j \neq i}^m \frac{I_h(i, j)}{m \cdot (m-1)}}$$

The function $I_h(i, j)$ is 1 if $d(x_i, x_j) < h$ and is 0 if $d(x_i, x_j) \geq h$ where the random points are $\{x_i\}_{i=1}^m$. The n in the formula is given by $n = 2$ if the points are in a planar area or $n = 3$ if in a three-dimensional area.

Suppose that the points are distributed randomly based on Hausdorff measure on a self-similar fractal. Would some analysis similar to the Ripley k -function apply in this case? We can show that such a random set of points can be used to give a reliable estimate of the Hausdorff dimension of the self-similar fractal. We will explain the theory and demonstrate its implementation. We will also discuss applications of the theory. (Received December 03, 2012)

65 ► *Numerical analysis*

1087-65-15 **I Alolyan*** (ialolyan@ksu.edu.sa), King Abdulaziz St # 25, Riyadh, 11451, Saudi Arabia. *Zeros of Interval Polynomials.*

In this paper, we study the zeros of interval polynomials. We develop a method to compute all zeros of such polynomial with interval coefficients and give the characterization of the roots. (Received October 27, 2012)

1087-65-222 **Dmitry Kurochkin*** (dkurochk@tulane.edu), 6823 St. Charles Ave, New Orleans, LA 70118, and **Alexander Kurganov** (kurganov@tulane.edu), 6823 St. Charles Ave, New Orleans, LA 70118. *Metropolis-Hastings Algorithm for Control Problems Constrained by Systems of Hyperbolic PDEs.*

Control problems constrained by systems of conservation or balance laws are considered. The problem is equivalent to minimizing an objective functional subject to the system of the hyperbolic PDEs. A local minimum of the functional can be achieved using a gradient method by solving numerically the system of the PDEs forward and then the corresponding adjoint system backward in time. In order to obtain the global minimum, a Markov Chain Monte Carlo (MCMC) method, based on the Metropolis-Hastings algorithm, is applied prior to the gradient method. Being a convergent algorithm, the MCMC method is, however, might be very slow and even practically useless due to the extremely high dimensionality of the constrained optimization problem. In

this work, we study efficient choice of the proposal distributions including a proper (stochastic) clustering of the control parameters. The algorithm was applied to one-dimensional system of Euler Equations of ideal gas dynamics. (Received December 04, 2012)

91 ► *Game theory, economics, social and behavioral sciences*

1087-91-76 **Cyrus F Nourani*** (acdmkrd@gmail.com), PO Box, 190762, & SFU Burnaby, BC, Canada, San Francisco, CA 94119, and **Oliver Schulte** (o.schulte@cs.sfu.ca), Burnaby, BC, Canada. *Competitive Models, Descriptive Computing, and Nash Games*. Preliminary report.

A novel competitive learning with game tree computing techniques are developed on a descriptive game logic where model compatibility is characterized on von Neumann, Morgenstern, Kuhn game descriptions model embeddings. Encodings with a VMK game function situations on computable partition functions allow us to characterize embedded measures on discrete topologies and homotopy on game models. Novel payoff criteria on game trees and game topologies are obtained. Theorem A game tree is solved at a node iff there is an elementary embedding on the generic diagrams, sequentially upward to the node, corresponding to VMK played at the node, that solves the root node.

Theorem Let A be a set of actions, and let $u: B(A) \rightarrow \mathbb{R}$ be a continuous function. The u satisfies a payoff axiom iff there is an elementary embedding on the generic diagrams for M , sequentially upward to the node, corresponding to VMK played at the node that solves the root node. s_i is for a player.

Proposition A matrix game reaches a Nash equilibrium when all the player corresponding model diagram rows are defined and at least one player accomplishes the goal set(s). (Received November 28, 2012)

CHESTNUT HILL, MA, April 6–7, 2013

Abstracts of the 1088th Meeting.

00 ► General

1088-00-163 **Murray Carlson, Sheridan Titman and Cristian Ioan Tiu*** (ctiu@buffalo.edu), 366 Jacobs, School of Management, University at Buffalo, Buffalo, NY 14260. *Real Asset Values and Security Prices*. Preliminary report.

We provide theoretical models of capital flows between segmented markets in a general setting with limits to arbitrage. When, for example, the cost structure for transferring capital between private and public markets is non-convex, an equilibrium results in which public and private values can be different. We model these differences as arising from a differential in the discount rates appropriate for each sector. We characterize the equilibrium behavior of private and public discount rates when sufficiently large deviations in causes capital to flow to the high return sector. We empirically explore the implications of the model for Real Estate Investment Trust returns and premia to net asset value (NAV). We find support for previously undocumented nonlinearities in the drift of the REIT NAV premium that are predicted by our theoretical model. We also find evidence consistent with these nonlinearities giving rise to misspecification of the standard linear vector autoregression. (Received February 08, 2013)

1088-00-201 **Jim Gatheral*** (jim.gatheral@baruch.cuny.edu), Department of Mathematics Box 6-230, Baruch College, One Bernard Baruch Way, New York, NY 10010. *Arbitrage-free SVI volatility surfaces*.

In this talk we show how to calibrate the widely-used SVI parameterization of the implied volatility surface in such a way as to guarantee the absence of static arbitrage. In particular, we exhibit a large class of arbitrage-free SVI volatility surfaces with a simple closed-form representation. We demonstrate the high quality of typical SVI fits with a numerical example using recent SPX options data. (Received February 10, 2013)

1088-00-206 **Bjorn Poonen*** (poonen@math.mit.edu), MIT 2-244, 77 Massachusetts Ave, Cambridge, MA 02139-4307. *Some undecidable problems*.

In many subfields of mathematics, certain problems have turned out to be undecidable. I will present a survey on some of these, and discuss other problems whose decidability status is still unknown. (Received February 11, 2013)

1088-00-224 **David Garber** (garberad@gmail.com), **Delaram Kahrobaei** (dkahrobaei@gc.cuny.edu) and **Ha T Lam*** (hatlam@gmail.com). *Polycyclic group-based cryptosystems (using conjugacy search problem) are secure against Length Based attacks*. Preliminary report.

After the Anshel-Anshel-Goldfeld (AAG) key-exchange protocol came out in 1999, it was studied with braid groups and then with Thompson's group as the underlying platform. The length-based attack, first originated by Hughes and Tannenbaum, has been used to extensively study AAG with the braid group platform. Meanwhile, a new platform, using polycyclic groups, was proposed by Eick and Kahrobaei. In this talk, we show the result of our study of the resistance of AAG with polycyclic group platform under the length-based attack. In particular polycyclic groups could provide a secure platform for any cryptosystem based on conjugacy search problem. (Received February 11, 2013)

1088-00-226 **Bren B Cavallo*** (bcavallo@gc.cuny.edu), PhD Program in Mathematics, CUNY Graduate Center, 365 Fifth Ave, New York, NY 10016. *Secret Sharing Using Non-Commutative Groups*. Preliminary report.

Secret sharing has a wide variety of important applications in cryptography. Recently Habeeb-Kahrobaei-Shpilrain introduced a method of secret sharing using non-commutative groups. In this talk I will show a variation on their method using the Shortlex Ordering on free groups and possibly indicate some new directions in the field. (Received February 11, 2013)

1088-00-233 **Delaram Kahrobaei*** (dkahrobaei@gc.cuny.edu), PhD Program in Computer Science, CUNY Graduate Center, 365 Fifth Ave, New York, NY 10016, and **Charalambous Koupparis**. *Non-commutative Digital Signatures*.

In this talk I will survey several digital signatures proposed in the last decade using non-commutative groups and rings and propose a digital signature using non-commutative groups and analyze its security. (Received February 11, 2013)

01 ► *History and biography*

1088-01-15 **John W Dawson*** (jwd7too@comcast.net), 393 Waters Road, York, PA 17403. *Alternative proofs in mathematical practice*. Preliminary report.

Since ancient times, new proofs of previously established results have held an esteemed place in mathematical practice. Why? What purposes do such alternative proofs serve? And how do mathematicians decide whether two proofs of a given theorem are significantly different? The formal notion of proof employed in mathematical logic was not designed to address such questions and seems ill suited to that task. If, instead, proofs are understood informally as arguments accepted as convincing by consensus of the mathematical community at a given time, then consideration of case studies of alternative proofs of various well-known theorems suggests how informal criteria can be used to analyze differences among proofs and to compare their merits. (Received November 24, 2012)

1088-01-16 **Scott B. Guthery*** (sbg@acw.com), Scott B. Guthery, 2400 Beacon #208, Chestnut Hill, MA 02467. *Mathematical Tables in Nineteenth Century America*.

The nature of the mathematical tables used in a scientific, engineering or commercial enterprise is one indicator of the degree to which quantitative methods are used as well as the maturity of those methods. In this talk we survey the mathematical tables in the catalogs of some early American libraries, with an emphasis on the catalogs of the Boston Athenæum, to characterize the use of quantitative methods in various endeavors in nineteenth century America. While the scientists, engineers and businessmen of the young nation were cognizant of computational developments in Europe, they were not reluctant to strike out on their own. Defining an American identity in science, engineering, and commerce was just as much a part of the spirit of the time as defining an American identity in art and literature. Stories include connection of Gaspard de Prony with a New England textile mill and the construction of the first table of prime factors in America by a Baltimore lawyer. (Received November 30, 2012)

1088-01-26 **Amy Ackerberg-Hastings*** (aackerbe@verizon.net). *Sectors at the Smithsonian*.

As part of an ongoing effort to re-catalogue mathematical objects for collections.si.edu and americanhistory.si.edu/collections/object-groups, I recently examined the National Museum of American History's collection of 23 sectors. A calculating instrument composed of two legs joined by a pivot point, the sector was invented in Europe in the late sixteenth century and proved especially useful for gunnery, surveying, and navigation. The examples owned by the Smithsonian are made of brass, wood, or ivory and date from the 1680s to the 1840s. The sets of scales on these sectors fall into three styles: Italian, French, and English. The instruments thus suggest national differences in approaches to practical mathematics in the early modern period. This talk shares observations about the collection and, perhaps more importantly, images of the objects. (Received January 05, 2013)

1088-01-38 **Chris Rorres*** (crorres@comcast.net). *Correcting an Error in Book I of Archimedes' "On Floating Bodies"*. Preliminary report.

Archimedes is credited with quantifying the concept of the center of gravity of an object and in his works he determined the locations of the centers of gravity of many planar and solid bodies. His calculations, however, implicitly assumed that the bodies were immersed in a uniform gravitational field, so he was actually determining the locations of their centers of mass (or centroids). He did not realize that the concept of a center of gravity is not applicable in a nonuniform gravitational field, a fact that many are not aware of even today. This led to his incorrectly proving an erroneous theorem at the end of Book 1 of his work "On Floating Bodies". His theorem states that a truncated sphere floating in a body of water on a spherical earth that attracts objects to its center will float stably with its base horizontally under very general conditions. I'll discuss his error and suggest an alternate proof of a similar correct result. (Received January 21, 2013)

1088-01-41 **Lawrence A. D'Antonio*** (ldant@ramapo.edu), 24 Meadowway, Dobbs Ferry, NY 10522. *A Pox on Both Your Houses! The Bernoulli – d'Alembert Smallpox Inoculation Controversy.*

Smallpox was a terrible scourge in the 18th century. Prior to the Jenner vaccine, an inoculation method was used to combat the disease. This method consisted in taking material drawn from a person infected with smallpox then rubbing that material into a scratch made on the hand of a healthy person. The latter would then develop a hopefully mild case of smallpox and thereafter be immune to reinfection. Daniel Bernoulli presented a memoir before the Paris Academy of Sciences in 1760 which developed a mathematical model of the propagation of smallpox, including the average increase in life expectancy for those who received an inoculation. D'Alembert vigorously attacked Bernoulli's theory, on mathematical grounds for Bernoulli's assumptions about the rates of infection and death from smallpox. He also attacked Bernoulli's theory from a utility argument. For someone who is young when considering inoculation, the fear of dying from the inoculation, not unfounded, may psychologically outweigh the expected gain in lifespan. In this talk we will discuss the rancorous dispute between Bernoulli and d'Alembert, which followed earlier quarrels on the St. Petersburg paradox and the vibrating string. We will also mention work by Jurin, Lambert, and Laplace related to this controversy. (Received January 22, 2013)

1088-01-53 **David Lindsay Roberts*** (robertsdl@aol.com). *Mathematics as Mind Training: The History of a Complex of Educational Ideas.* Preliminary report.

When doubts have arisen as to the practical utility of learning mathematics, promoters of this learning have often had recourse to claiming that mathematics trains the mind, or the character, or both. In this talk we will survey the history of educational debates surrounding such ideas, mainly in the United States, over the past 200 years. (Received January 29, 2013)

1088-01-55 **Christopher J. Phillips*** (phillips@fas.harvard.edu), Science Center 371, One Oxford St., Cambridge, MA 02138. *Soldiers and Scholars: Descriptive Geometry on the Blackboard.*

Blackboards are crucial components of the practice of mathematics. It would be a mistake, however, to assume that the ways in which they represent, aid, or even augment mental processes have been constant over time. This paper uses one specific, but important, site of the blackboard's development and deployment—the United States Military Academy at West Point—to explore how the blackboard came to be seen in the nineteenth century as a tool that made visible otherwise hidden intellectual, moral, and physical characteristics. At the heart of the story is descriptive geometry, a subject which played an important role at West Point in large part because of the claims made for it by Gaspard Monge at the Ecole Polytechnique. For Monge, descriptive geometry was as much a political intervention as a technical practice, ideally suited to preparing students for careers in “public service.” It was also a visual subject which required mastery of both head and hand, and thereby which complemented the new technology of the blackboard. Nineteenth-century West Point provides an important case study for situating the blackboard within mathematical practice and pedagogy. (Received January 30, 2013)

1088-01-56 **Jean-Pierre Marquis*** (jean-pierre.marquis@umontreal.ca), Département de philosophie, Université de Montréal, C.P. 6128, succ. Centre-ville, Montréal, Québec H3C 3J7, Canada. *The abstract method and the nature of mathematical abstraction in 20th century mathematics.*

In this talk, I will look at some of the historical elements that gave rise to the abstract method in the 20th century and I will consider it from a philosophical point of view. From the elements gathered from the history of mathematics, I will propose a theory of abstraction which is essentially epistemological, though it has logical implications. I will consider how this theory allows us to explain some of the historical components as well as philosophical and cognitive elements involved in the abstract method. (Received January 30, 2013)

1088-01-69 **Joseph W. Dauben***, Department of History, Herbert H. Lehman College, CUNY, 250 Bedford Blvd. Part West, Bronx, NY 10468. *The Evolution of Mathematics in Ancient China: From the Newly Discovered Shu and Suan shu shu Bamboo Texts to the Nine Chapters on the Art of Mathematics.* Preliminary report.

The history of ancient Chinese mathematics and its applications has been greatly stimulated in the past few decades by remarkable archaeological discoveries of texts from the pre-Qin and later periods that for the first time have made it possible to study in detail mathematical material from the time at which it was written. By examining the recent Warring States, Qin and Han bamboo mathematical texts currently being conserved and studied at Tsinghua University and Peking University in Beijing, the Yuelu Academy in Changsha, and the Hubei Museum in Wuhan, it is possible to shed new light on the history of early mathematical thought and its applications in ancient China. Attention will also be focused on the development of techniques and justifications

given for the problems that were a growing part of the corpus that eventually culminated in the comprehensive *Nine Chapters on the Art of Mathematics*. (Received February 02, 2013)

1088-01-104 **Hardy Grant***, hardygrant@yahoo.com. "*Epistemic Cultures*" and the History of *Mathematics*. Preliminary report.

The sociologist Karin Knorr Cetina uses the term "epistemic cultures" for "those amalgams of arrangements and mechanisms ... which, in a given field, make up how we know what we know"; her primary focus is the laboratories of physical science. The concept's historiographical significance is that the specifics of such a culture – its ontological assumptions, its internal dynamics – are taken to shape crucially the knowledge which emerges. A recent workshop at the University of Toronto, organized by Josipa Petrunic, sought to explore the question to what extent #mutatis mutandis# such "mechanisms of knowledge construction" can be identified in mathematics. I shall try to sketch the attendant issues and to suggest some candidates. (Received February 05, 2013)

1088-01-135 **Dick Jardine*** (rjardine@keene.edu), Mathematics Department, Keene State College, 229 Main Street, MS2010, Keene, NH 03435. *Episodes from American Mathematics in the Age of Jefferson*. Preliminary report.

Thomas Jefferson wrote 18,624 letters in his lifetime, according to an estimate by one editor of his papers. A portion of that voluminous correspondence included mathematical topics and identified mathematicians of the day, those considered to be mathematicians in that time and place. Due to Jefferson's interest in the mathematics of surveying, the correspondence includes applications of the calculus and Napier's theorem, both of which will be discussed in this presentation. (Received February 07, 2013)

1088-01-174 **Duncan J Melville*** (dmelville@stlawu.edu), Dept. of Mathematics, St. Lawrence University, Canton, NY 13617. *Perspective, Painting, Publishing, and Patronage: Joshua Kirby and Brook Taylor*.

The theory of perspective stands at an unusual intersection of mathematics and art. Its expositors have to balance mathematical sophistication and abstraction with practical utility. Brook Taylor's 1715 *Linear Perspective* is austere and rigorous, but was more admired than applied. Joshua Kirby's later adaptation of Taylor's approach achieved wider circulation, and secured personal advancement for the author. I discuss Taylor's innovations, Kirby's adaptation, and the market for knowledge in the 1750s. (Received February 09, 2013)

1088-01-182 **Eisso J Atzema*** (atzema@math.umaine.edu), Department of Mathematics and Statistics, University of Maine, Orono, ME 04469. *Learning vector calculus circa 1900*. Preliminary report.

Various forms of vectorial thinking arose in the mid-19th century and mathematicians and physicists alike were quick to reformulate "classical" multi-variable calculus to reflect this new notion and to turn this new vector calculus into a powerful analytical tool. As much agreement as there was within the mathematical community as to the usefulness of the new calculus, there was little consensus regarding the precise formulation of the new vectorial notions and no agreement at all on notation. Even the notions used for the vectors themselves widely varied from country to country, or even from author to author. Any learner of the new calculus would have had a hard time to even recognize the commonalities between the various expositions that would have been available to them by the 1900s. In this talk I will discuss how an American student would have gone about learning vector calculus circa 1900 and how the standard curriculum at the time would have prepared them for that experience. (Received February 10, 2013)

1088-01-250 **Andrew P Fiss*** (anfiss@vassar.edu), Box 353, Vassar College, 124 Raymond Avenue, Poughkeepsie, NY 12604-0353. *The Burial of Euclid: Defacing Geometry in Early-Nineteenth-Century America*. Preliminary report.

Every year from about 1830 to 1863, Yale sophomores gathered for an elaborate "farce-tragedy" to deface and destroy their textbooks of Euclidean geometry. Late some autumn night, dressed in demonic masks and costumes, they would march northeast from campus towards the Masonic temple. To melodies from school songs or minstrel acts, they would sing allusions to blackboards, geometrical figures, and the translator John Playfair. The 1850 celebration, for instance, contained a parody of "O Susanna" that began "No more we gaze upon that board/ Where oft our knowledge failed,/ As we its mystic lines ignored,/ On cruel points impaled./ We're free! Hurrah! from Euclid free!/ Farewell, misnamed Playfair,/ Farewell, thou worthy Tutor B.,/ Shake hands and call it square." After a pseudo-Hellenistic burial procession, the students would burn and/or bury the effigy, often the textbook. This ritual, practiced at Yale and elsewhere, communicated not just the students' hatred of their mathematical classes. In indicating the connections between classical and mathematical study, such traditions

ultimately served not to deconstruct but rather to reaffirm the missions of American men's colleges in the early nineteenth century. (Received February 11, 2013)

1088-01-278 **Brittany Shields*** (bshields@sas.upenn.edu). *Émigré Mathematicians: Richard Courant and the Mathematical Institutes at the University of Göttingen in Germany and New York University*.

As Felix Klein's successor, Richard Courant (1888-1972) served as the director of the Mathematical Institute at the University of Göttingen for several years in the 1920s and 1930s. During this time, the institute was prolific. Courant's doctoral advisor, David Hilbert, along with Hermann Weyl, Emmy Noether, and other prominent mathematicians, cultivated a dynamic community of mathematicians. In 1929, the institute moved into its own academic building – sponsored mainly by the Rockefeller Foundation and designed specifically for the mathematicians. Just several years later, in April of 1933, Courant was dismissed from his position by the Nazi government. After spending the following academic year at the University of Cambridge, Courant came to the United States. Joining the faculty of New York University in 1934, Courant was commissioned to develop a graduate program in mathematics. Over the following decades, Courant, in collaboration with Kurt O. Friedrichs and James J. Stoker, established a mathematical institute at New York University which emulated the Göttingen Mathematical Institute. This paper will focus on the cultural and social history of émigré mathematicians by analyzing Courant's career and the Mathematical Institutes at Göttingen and NYU. (Received February 12, 2013)

1088-01-285 **Kim Plofker*** (kim_plofker@alumni.brown.edu), Department of Mathematics, Union College, 807 Union Street, Schenectady, NY 12308. *Pre-computer number crunching: computational aids and techniques in Indian mathematics*. Preliminary report.

The advent of mechanized and electronic calculating devices has made it easy to forget or ignore how much work even relatively simple mathematical computations used to involve. Pre-modern mathematicians expended considerable time and ingenuity in constructing numerical tables of function values to use in such computations. This talk explores some of the methods and tricks used by late medieval and early modern Indian mathematicians to make calculation-intensive tasks easier. (Received February 12, 2013)

03 ► *Mathematical logic and foundations*

1088-03-81 **Antonio Montalbán** and **Richard A. Shore*** (shore@math.cornell.edu), Department of Mathematics, Malott Hall, Cornell University, Ithaca, NY 14853. *The Limits of Determinacy in Second Order Arithmetic: Consistency and Complexity Strength*. Preliminary report.

We study the consistency and reverse mathematical strength of low levels of determinacy axioms. We derive our results by a recursion/complexity theoretic analysis.

Determinacy for all Boolean combinations of $F_{\sigma\delta}$ (Π_3^0) sets implies the consistency of second-order arithmetic and more. Indeed, it is equivalent to the existence, for every set X and $n \in \mathbb{N}$, of a β -model of Π_n^1 -comprehension containing X . We prove this by providing a level-by-level analysis of determinacy at the finite level of the difference hierarchy on Π_3^0 sets: For $n \geq 1$, determinacy at the n th level lies strictly between the existence of β -models of Π_{n+2}^1 -comprehension containing any given set X and of such models of Δ_{n+2}^1 -comprehension. Thus it lies strictly between Π_{n+2}^1 -comprehension and Δ_{n+2}^1 -comprehension in consistency strength. The major new technical result is a recursion/complexity theoretic one. The n th determinacy axiom implies closure under the operation taking a set X to the least Σ_{n+1} admissible containing X (for $n = 1$, this is due to Welch [2012]). (Received February 04, 2013)

1088-03-111 **Francine F. Abeles*** (fabeles@kean.edu), 1000 Morris Avenue, Union, NJ 07083. *Hypotheticals, Conditionals, and the Implication Relation in Pre-Boolean 19th Century British Logic*. Preliminary report.

Among the principal interpreters of traditional logic in England in the first half of the 19th century were Richard Whately, William Hamilton, John Mill, and Augustus De Morgan who also considered probable premises. In this paper, I will present their views on hypotheticals, conditionals, and the implication relation. (Received February 05, 2013)

1088-03-132 **Nathanael Ackerman*** (nate@math.harvard.edu), Harvard University, Department of Mathematics, Cambridge, MA 02138. *Computability of 0-1 Laws.*

One of the most remarkable results in finite model theory is that for any first order sentence φ ,

$$\lim_{n \rightarrow \infty} \frac{|\{M \models \varphi : |M| = n\}|}{|\{M : |M| = n\}|}$$

is either 0 or 1. In other words, any sentence is realized asymptotically almost surely (a.a.s.) or asymptotically almost never among all finite structures (of a fixed language). This is called the 0-1 law for first order logic. Since its discovery, several other 0-1 laws have been identified for other collections of finite structures, such as finite graphs, finite triangle-free graphs, and finite partial orders.

Given any complete first order theory T , we can look at the collection of finite subsets of infinite models of T , $\mathcal{C}(T)$, and ask which sentences hold a.a.s. This gives us a map $L^{0,1}(\cdot)$ which takes a complete theory and returns the collection of sentences which hold a.a.s. of structures in $\mathcal{C}(T)$. We can then ask “How computable can the output $L^{0,1}(T)$ be, when the input T is a computable complete theory and $\mathcal{C}(T)$ satisfies a 0-1 law?”

In this talk we will formalize these concepts and provide a complete answer to this question. (Received February 07, 2013)

1088-03-220 **Brooke M Andersen*** (brandersen@assumption.edu), 500 Salisbury Street, Worcester, MA 01520. *Using complete sets to distinguish reducibilities.*

We discuss using complete sets to distinguish strong notions of reducibility. In particular, we look at D^+ reducibility, and compare this reducibility to other (positive) notions of reducibility. (Received February 11, 2013)

1088-03-238 **Rehana Patel*** (rehana.patel@olin.edu), F.W. Olin College of Engineering, Olin Way, Needham, MA 02492. *A Random Walk Through Zero-One Laws for Classes of Graphs with a Forbidden Subgraph.*

A collection \mathcal{C} of finite structures has a *first order labeled zero-one law* if, for any first order sentence φ (in an appropriate language), the proportion of n -element structures in \mathcal{C} that satisfy φ has limiting value either 0 or 1, as $n \rightarrow \infty$. The classic example of such a collection is when \mathcal{C} consists of (the isomorphism types of) all finite graphs. Kolaitis, Prömel and Rothschild have shown, building on work of Erdős, Kleitman and Rothschild, that for each $\ell \geq 3$, the class of all finite K_ℓ -free graphs has a first order labeled zero-one law. The question then arises: For which graphs H , other than $H = K_\ell$, does the class of all finite H -free graphs admit such a zero-one law? In this talk we will survey the cases known to the speaker, providing a partial catalog, and outline some conjectures and possible approaches to resolving them. (Received February 11, 2013)

1088-03-263 **Johanna N.Y. Franklin*** (johanna.franklin@uconn.edu), Department of Mathematics, 196 Auditorium Road, University of Connecticut, Unit 3009, Storrs, CT 06269-3009, and **Keng Meng Ng.** *Weak Demuth randomness and computational strength.*

Strong randomness notions tend to correspond to low computational strength. For instance, a real is difference random if and only if it is Martin-Löf random and does not compute $0'$, and a real is weakly 2-random if and only if it is Martin-Löf random and does not compute any nonrecursive r.e. set. We will present a similar characterization of weak Demuth randomness: a real is weakly Demuth random if and only if it is Martin-Löf random and does not compute any strongly prompt r.e. set. (Received February 12, 2013)

05 ► Combinatorics

1088-05-23 **Olivier Bernardi** (bernardi@brandeis.edu), Brandeis University, Department of Mathematics, Waltham, MA, and **Alejandro H. Morales*** (ahmorales@lacim.ca), Laboratoire de Combinatoire et d'informatique, Université du Québec à Montréal, Montreal, QC, Canada. *Bijections and symmetries for the factorizations of the long cycle.*

We study the factorizations of the permutation $(1, 2, \dots, n)$ into k factors of given cycle types. Using representation theory, Jackson obtained for each k an elegant formula for counting these factorizations according to the number of cycles of each factor. In the cases $k = 2, 3$ Schaeffer and Vassilieva gave a combinatorial proof of Jackson's formula, and Morales and Vassilieva obtained more refined formulas exhibiting a surprising symmetry property. These counting results are indicative of a rich combinatorial theory which has remained elusive to this point, and it is the goal of this project to establish a series of bijections which unveil some of the combinatorial properties of these factorizations into k factors for all k . The first bijection is an instance of a correspondence of Bernardi between such factorizations and tree-rooted maps; certain graphs embedded on surfaces with a distinguished spanning tree. (Received December 18, 2012)

1088-05-28 **Gabe Cunningham*** (gabriel.cunningham@gmail.com). *Orbit graphs and face-transitivity of k -orbit polytopes.*

The orbit graph of a k -orbit polytope is a graph on k nodes that shows how the flag orbits are related by flag adjacency. Using orbit graphs, we classify k -orbit polytopes and determine when a k -orbit polytope is i -transitive. We then provide an explicit classification of three-orbit polytopes, and we describe a generating set for their automorphism groups. (Received January 14, 2013)

1088-05-72 **Fatimah Ahmed Alsmael, Christopher E. Creighton, Bogdan Gheorghe and Kyungyong Lee*** (klee@math.wayne.edu). *Equations for isospectral Hilbert schemes of $n \leq 4$ points on the plane.* Preliminary report.

Let I_n be the ideal generated by alternating polynomials in two sets of n variables. I will talk about work in progress where we are trying to give a combinatorial description for defining equations for the Rees algebra of I_n for $n \leq 4$. (Received February 02, 2013)

1088-05-114 **Thomas W. Tucker*** (ttucker@colgate.edu), Mathematics Department, Colgate University, Hamilton, NY 13346. *From maps to polytopes.* Preliminary report.

Three recent results about maps are presented: 1) all but finitely many maps have distinguishing number two; 2) the clique number of a regular (reflexible) map is 2, 3, 4 or 6; 3) the only polyhedral orientably regular maps M of genus g with $|Aut^o(M)|$ coprime to $g - 1$ are the Platonic solids. The analogues for polytopes are considered and the obstacles to their proof are analyzed. (Received February 05, 2013)

1088-05-144 **Jonathan Novak*** (jnovak@math.mit.edu), Massachusetts Institute of Technology, Building 2, 77 Massachusetts Avenue, Cambridge, MA 02139. *An invitation to the Weingarten calculus.*

A number of techniques have been developed in recent years to deal with the problem of integrating polynomial functions on classical matrix groups, such as the orthogonal, unitary and symplectic groups. The computation of such integrals is required in random matrix theory and related areas, and the tools which have been developed to deal with this problem have now been codified into a more or less complete framework - the Weingarten calculus. I will give an introduction to this topic, focusing on its interaction with algebraic combinatorics. My talk is based on a book in preparation with Benoit Collins and Sho Matsumoto. (Received February 07, 2013)

1088-05-158 **Luis A. Ruiz-Lopez*** (lruiz@matmor.unam.mx), Guadalupe Victoria 598, 58130 Morelia, Michoacan, Mexico. *Quotients of abstract regular polytopes by linear codes.* Preliminary report.

In this talk we will deal with quotients of abstract polytopes whose automorphism groups contain linear codes as subgroups. The special case where the codes are binary was previously studied by Egon Schulte. We will extend the ideas of Schulte to other family of polytopes whose automorphism groups contain codes over other finite fields. (Received February 08, 2013)

1088-05-180 **Leah Wrenn Berman** (wberman@alaska.edu), Department of Mathematics and Statistics, Fairbanks, AK 99775, **Mark Mixer** (mark.mixer@williams.edu), Mathematics and Statistics, Williams College, Williamstown, MA 01267, **Barry Monson** (bmonson@unb.ca), University of New Brunswick, Fredericton, NB. E3B 5A3, **Deborah Oliveros*** (dolivero@matem.unam.mx), Instituto de Matematicas, Universidad Nacional Autonoma de Mexico, Area de la Investigacion Cientifica, CU, 04510 Mexico D.F., D.F., Mexico, and **Gordon Williams** (giwilliams@alaska.edu), Department of Mathematics and Statistics, Fairbanks, AK 99775. *The monodromy group of pyramids.* Preliminary report.

The monodromy group of an abstract polytope, is a subgroup of the symmetric group acting on all flags of the polytope, that encodes the essential combinatorial features of it, and says a lot about how the polytope can be covered by a regular d -polytope. In this talk, we will discuss the monodromy group $Mon(\mathcal{P}_n)$ of an ordinary 3-dimensional pyramid \mathcal{P}_n , that is, the convex hull of a regular n -gon with a single new vertex placed directly above the center of the n -gon, at any height. (Received February 10, 2013)

1088-05-248 **Val Pinciu*** (pinciuv1@southernct.edu). *A Note on the Prison Yard Problem.*

The prison yard problem asks for the minimum number of vertex guards that are always sufficient and sometimes necessary to protect both the interior and the exterior of a polygon (the prison yard) with n sides. We slightly improve the best known upper bound for the orthogonal prison yard problem. We use a graph coloring argument to prove that an orthogonal prison yard with n sides can always be protected by $\lfloor 5n/12 \rfloor + 1$ vertex guards. This is joint work with T. S. Michael. (Received February 11, 2013)

1088-05-268 **Ilanit Helfand*** (ilanit.helfand@gmail.com). *Subdivision in Abstract Polytopes.*

In contrast to the study of convex polytopes, the study of abstract polytopes allows two 2-faces to intersect in more than one edge. This generality permits us to apply the idea of edge subdivision to abstract polytopes. That is, we can add a vertex to the interior of an edge, thus replacing the edge with two new edges and a new vertex. We will explore the impact of subdivision on symmetries of polytopes, and discuss how we can generalize this construction. Additionally, we will talk about a construction which produces polytopes which are dual to subdivided polytopes. We will also discuss the relationship between subdivided polytopes and Kleetopes. (Received February 12, 2013)

1088-05-274 **Amanda Redlich*** (aredlich@math.rutgers.edu). *A Combinatorial Toolkit for Nonlinear Analysts.*

The talk will be at an introductory level, with the aim of motivating further exploration and collaboration between researchers in both fields. We survey several useful concepts from combinatorics. We also briefly discuss applications of these ideas to integrability questions. Topics covered will include Grassmannians, permutations, planar graphs, and Young tableaux. (Received February 12, 2013)

1088-05-276 **Jessica Striker***, jessica@math.umn.edu. *The toggle group and its application to statistical physics.*

We introduce the toggle group, which acts on the order ideals of a partially ordered set, or poset. We use the toggle group to model actions on various objects important in combinatorics and statistical physics, including rotation of noncrossing matchings and gyration on fully-packed loops. This is based on joint work with Nathan Williams. (Received February 12, 2013)

1088-05-286 **Michael La Croix*** (malacroix@alumni.uwaterloo.ca). *β -Gaussian Ensembles and the Non-orientability of Polygonal Glueings.*

The moments of the GOE have a combinatorial interpretation in terms of the number of ways a collection of decorated polygons can be glued together to produce surfaces, while the corresponding moments of the GUE have a similar interpretation in terms of the number of ways such polygons can be glued together to produce orientable surfaces. In fact, it is possible to study the moments of the two ensembles simultaneously in terms of β -Gaussian ensembles, a 1-parameter family characterized by joint eigenvalue densities proportional to

$$\prod_{1 \leq i < j \leq N} |x_i - x_j|^\beta \exp\left(-\frac{\beta}{4} \sum_{i=1}^N \frac{x_i^2}{2}\right),$$

that coincides with the GOE when $\beta = 1$ and with the GUE when $\beta = 2$. By describing a suitable way to measure the departure of a polygonal glueing from orientability, I will show that the combinatorial interpretation extends naturally to an interpretation of the moments of β -Gaussian ensembles, which are non-negative integer polynomials in the parameters N and $b = \frac{2}{\beta} - 1$, and discuss some of the implications of this fact. (Received February 12, 2013)

06 ► Order, lattices, ordered algebraic structures

1088-06-116 **Marston Conder*** (m.conder@auckland.ac.nz), Mathematics Department, University of Auckland, Private Bag 92019, Auckland, 1142, New Zealand, and **Deborah Oliveros**. *The intersection condition for regular polytopes.*

The automorphism group of a regular polytope is a smooth quotient of a string Coxeter group (with a linear Dynkin diagram). Conversely, any finite smooth quotient of such a group is the automorphism group of a regular polytope, provided that it satisfies the so-called ‘intersection condition’. I will describe some recent discoveries about the intersection condition, especially in ranks 3 and 4, and its application to find the smallest regular polytopes of any given rank. (Received February 06, 2013)

11 ► Number theory

1088-11-31 **Liljana Babinkostova, Kevin Bombardier, Matthew Cole, Thomas Morrell*** (tmorrell@wustl.edu) and **Cory Scott**. *Elliptic Reciprocity.*

We define the notions of an elliptic pair, an elliptic list, and an elliptic cycle over a square-free positive integer d , concepts related to the notions of amicable pairs and aliquot cycles for elliptic curves introduced by Silverman and Stange. We then settle a question left open by Silverman and Stange, using elliptic pairs to show that for

$d = 3$ (in particular, $j = 0$) there exist elliptic cycles of length six, thereby proving that there exist aliquot cycles of length greater than two for elliptic curves with complex multiplication. We further explore the connections between elliptic lists and quadratic prime-generating polynomials, deriving an upper bound for the lengths of the lists as a function of d . (Received January 15, 2013)

1088-11-34 **Simon Marshall*** (s1m@math.northwestern.edu), Department of Mathematics, Northwestern University, 2033 Sheridan Road, Evanston, IL 60208. *Multiplicities of automorphic forms on GL_2 .*

I will discuss some ideas related to the theory of p -adically completed cohomology developed by Frank Calegari and Matthew Emerton. If F is a number field that is not totally real, I will use these ideas to prove a strong upper bound for the dimension of the space of cohomological automorphic forms on GL_2 over F that have fixed level and growing weight. (Received January 19, 2013)

1088-11-37 **Joseph H Silverman*** (jhs@math.brown.edu), Mathematics Department, Box 1917, Brown University, Providence, RI 02912. *Dynamical Degrees and Arithmetic Degrees for Rational Maps and Morphisms.*

Let $f : X \dashrightarrow X$ be a dominant rational self-map of a smooth projective N -dimensional variety defined over $\overline{\mathbb{Q}}$. The dynamical degree $\delta_f = \lim((f^n)^*H \cdot H^{N-1})^{1/n}$ of f measures the dynamical complexity of the iterates f^n of f . The arithmetic degree $\alpha_f(x) = \lim h_X(f^n(x))^{1/n}$ of a point $x \in X(\overline{\mathbb{Q}})$ similarly measures the arithmetic complexity of the f -orbit $\mathcal{O}_f(x)$ of x . I will discuss the inequality $\alpha_f(x) \leq \delta_f$, the conjecture that $\alpha_f(x)$ is an algebraic integer (and the proof if f is a morphism), and the conjecture that if $\mathcal{O}_f(x)$ is Zariski dense, then $\alpha_f(x) = \delta_f$ (with a proof when X is a power of a non-CM elliptic curve). This is joint work with Shu Kawaguchi. (Received January 20, 2013)

1088-11-39 **Joel Bellaïche*** (jbellaic@brandeis.edu), 15 Ridge Rd, Branford, CT 06405. *On the parity of coefficients of modular forms.*

Building on the recent determination of the Hecke algebra acting on modular forms of level 1 modulo 2, by Nicolas and Serre, and on the construction of a natural Galois representations on this algebra, we will study the parity of coefficients of modular forms. (Received January 21, 2013)

1088-11-40 **Gautam Chinta***, CCNY, Dept of Math, New York, NY 10025. *Zeta functions of cubic rings.*

I will describe how to study zeta functions of cubic rings using the zeta function of a prehomogeneous vector space. This is joint work with Takashi Taniguchi (Kobe). (Received January 22, 2013)

1088-11-48 **Andrew V Sutherland*** (drew@math.mit.edu), Department of Mathematics, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02138. *Computing images of Galois representations attached to elliptic curves.* Preliminary report.

Let ℓ be a prime, and let E/\mathbb{Q} be an elliptic curve. The action of the absolute Galois group $\text{Gal}(\overline{\mathbb{Q}}/\mathbb{Q})$ on the ℓ -torsion subgroup $E[\ell]$ induces a group representation $\rho_{E,\ell} : \text{Gal}(\overline{\mathbb{Q}}/\mathbb{Q}) \rightarrow \text{Aut}(E[\ell]) \simeq \text{GL}_2(\mathbb{Z}/\ell\mathbb{Z})$. According to a conjecture of Serre, there is a finite list of groups that ever arise as the image of a non-surjective representation $\rho_{\ell,E}$ for an elliptic curve E/\mathbb{Q} without complex multiplication. As a first step toward computing this set, I will describe a highly efficient algorithm for computing $\rho_{\ell,E}$ (up to isomorphism and usually up to conjugacy) for all primes ℓ up to a given bound and all elliptic curves E in a given family. I will then present results of this algorithm when applied to the elliptic curves in Cremona's tables and the Stein-Watkins database. Finally, I will briefly discuss generalizations to number fields, composite values of ℓ , and abelian varieties of higher dimension. (Received January 28, 2013)

1088-11-52 **David Hansen***, Department of Mathematics, Boston College, Chestnut Hill, MA 02467. *Analytic p -adic L -functions for GL_2 .*

I'll describe a construction which associates a canonical p -adic L -function with a "non-critically refined" regular algebraic cuspidal automorphic representation of GL_2/F over an arbitrary number field F . When $F = \mathbb{Q}$, this recovers a construction of Pollack and Stevens. These L -functions deform naturally into many-variable L -functions over eigenvarieties, and they satisfy good interpolation and growth properties; if F is totally real, these three requirements characterize our construction uniquely. (Received January 29, 2013)

1088-11-63 **Alan Koch*** (akoch@agnesscott.edu), Agnes Scott College, 141 E. College Ave., Decatur, GA 30030. *Matrices with correspond to Hopf orders in high ramification.* Preliminary report.

Let k be a perfect field, characteristic p , and fix a positive integer n . Pick $X \in M_n(k[[u]]) \cap \mathrm{GL}_n(k((u)))$. We show how X corresponds to an R -Hopf order in KC_p^n , where R is any characteristic zero discrete valuation ring with residue field k such that $e(K/\mathbb{Q}_p)$ is sufficiently large. This construction differs from the similar Childs/Underwood construction as it does not rely on a smooth resolution for the constructed Hopf algebra. We discuss when $X_1, X_2 \in M_n(k[[u]]) \cap \mathrm{GL}_n(k((u)))$ give the same R -Hopf order, and compare this construction to the case where $\mathrm{char} R = p$. (Received January 31, 2013)

1088-11-73 **Robert L. Benedetto*** (r1b@math.amherst.edu) and **Trevor G. Hyde.** *Computing new quadratic rational examples in arithmetic dynamics.* Preliminary report.

Consider pairs (ϕ, x) consisting of a quadratic rational function $\phi \in \mathbb{Q}(z)$ with rational coefficients, together with a rational point $x \in \mathbb{P}^1(\mathbb{Q})$, for which x is either preperiodic or has very small canonical height with respect to ϕ . In the preperiodic case, the length of the forward orbit of x is conjecturally bounded above; and in the non-preperiodic case, the canonical height, normalized with respect to the height of ϕ itself, is conjecturally bounded below. In this talk, we present a computational strategy for searching for such pairs (ϕ, x) . We also present some new examples for which the preperiodic orbit is large or the canonical height is small. (Received February 03, 2013)

1088-11-80 **Paul E. Gunnells** and **Dan Yasaki*** (d_yasaki@uncg.edu). *Modular Forms and Elliptic Curves Over the Cubic Field of Discriminant -23 .*

Let F be the cubic field of discriminant -23 and let $\mathcal{O} \subset F$ be its ring of integers. By explicitly computing cohomology of congruence subgroups of $\mathrm{GL}_2(\mathcal{O})$, we computationally investigate modularity of elliptic curves over F . (Received February 04, 2013)

1088-11-92 **Min Lee*** (minlee80@gmail.com), 151 Thayer St, Department of Mathematics, Brown University, Providence, RI 02912, and **Hee Oh.** *Effective circle count for Apollonian packings and closed horospheres.*

We prove an effective equidistribution of closed horospheres in the unit tangent bundle of a geometrically finite hyperbolic 3-manifold of infinite volume, whose fundamental group has critical exponent bigger than 1. As an application, we obtain an effective count for Apollonian circle packings. Non-effective versions of equidistribution and counting in this context were known previously. It is a joint work with Hee Oh. (Received February 04, 2013)

1088-11-102 **Louis Gaudet*** (louis.gaudet@yale.edu), P.O. Box 204174, New Haven, CT 06520, and **Olivia Beckwith, Amanda Bower, Rachel Insoft, Shiyu Li, Steven J. Miller and Philip Tosteson.** *The Average Gap Distribution for Generalized Zeckendorf Decompositions.*

A beautiful theorem of Zeckendorf states that every positive integer can be written uniquely as a sum of non-consecutive Fibonacci numbers F_n . Once this has been shown, it's natural to ask how many Fibonacci numbers are needed. Lekkerkerker proved that the average number of such summands needed for integers in $[F_n, F_{n+1})$ is $n/(\varphi^2 + 1)$, where φ is the golden mean. Previous approaches were through continued fractions, and limited to results on the number of summands. Using a combinatorial approach related to the cookie problem, we are able to obtain results on the distribution of gaps between summands in not just the Fibonacci case, but also for decompositions arising from more general linear recurrence relations. In particular, we show that the probability of observing a gap of size k essentially decreases geometrically in k , with the constant depending on the largest root of the characteristic polynomial of the recurrence. This is joint work with Professor Steven J. Miller and several of his REU students. The only background required is elementary probability and combinatorics. (Received February 05, 2013)

1088-11-107 **T Alden Gassert*** (gassert@math.umass.edu). *Discriminant Formula for Chebyshev Radical Extensions.*

Let $T_\ell^n(x) - t$ denote the n -th iterate of the Chebyshev polynomial of prime degree ℓ shifted by an arbitrary integer t . Assuming this polynomial is irreducible, let θ be one of its roots. For certain choices of t , we derive a closed formula for the discriminant of $K = \mathbb{Q}(\theta)$. In particular, we identify the precise conditions on t for which K is monogenic. (Received February 05, 2013)

1088-11-108 **G. Griffith Elder*** (elder@unomaha.edu) and **Nigel P. Byott**. *Scaffolds in local Galois module theory with implications for the classification of Hopf orders.*

The notion of a Galois scaffold, introduced in [Proc AMS 137 #4 (2009) 1193-1203] for elementary abelian p -extensions of local fields of characteristic p , is proving useful in local Galois module theory. For example, given a Galois scaffold, necessary and sufficient conditions on the ramification filtration can be given for the ring of integers in an extension of local fields to be free over its associated order. In this talk, I will explain how the notion of a Galois scaffold has been extended to general Galois p -extensions and also to other Hopf-Galois structures. I will describe necessary and sufficient conditions on the ramification filtration for the ring of integers to be free over its associated order. I will then discuss the problem of constructing a Galois scaffold in a given extension, and, using a result of Bondarko, discuss implications for the classification of Hopf orders in group rings. (Received February 05, 2013)

1088-11-130 **Ethan Berkove*** (berkove@lafayette.edu), Department of Mathematics, Lafayette College, Easton, PA 18045. *Equivariant cohomology of SL_2 over imaginary quadratic integers.* Preliminary report.

This is joint work with Alexander Rahm. Rahm has shown that given a Bianchi group ($\mathbb{P}SL_2$ over imaginary quadratic integers), its homology is determined by the group's torsion sub-complex, a complex related to the fundamental domain of the action of the Bianchi on hyperbolic 3-space. Recently, the authors have extended this result to determine cohomology of special linear groups over imaginary quadratic integers. In particular, the method provides general dimension formulae for cohomology coming from the equivariant spectral sequence of SL_2 groups via its tessellation on a retract of hyperbolic 3-space. (Received February 06, 2013)

1088-11-137 **Carl Pomerance*** (carl.pomerance@dartmouth.edu), HB 6188, Dartmouth College, Hanover, NH 03755. *The first dynamical system?*

For an integer n let $s(n)$ denote the sum of the divisors of n that are in $[1, n)$. Pythagoras noted 2500 years ago that $s(220) = 284$ and $s(284) = 220$, so that 220 and 284 are periodic under s -iteration with period 2. Such pairs, called *amicable*, were studied throughout antiquity. We now know over ten million amicable pairs but not if there are infinitely many. Euclid discussed the *perfect* numbers, namely the positive integers of period 1 in the s -dynamical system. He knew 4 perfect numbers; as of January, 2013 we know 48 of them, but not if there are infinitely many. The Catalan–Dickson conjecture asks if every integer is preperiodic under s ; that is, are there any infinite orbits? (The first number in doubt is 276.) Erdős asked if the set $\text{Per}(s)$ of periodic points (known as the *sociable* numbers) has asymptotic density 0. This talk will survey recent results on these and related questions. Much of this is joint work with Mitsuo Kobayashi and Paul Pollack. (Received February 07, 2013)

1088-11-154 **Alvaro Lozano-Robledo*** (alvaro.lozano-robledo@uconn.edu), 196 Auditorium Rd, U-3009, Department of Mathematics, University of Connecticut, Storrs, CT 06269. *On the field of definition of a p^n -torsion point on an elliptic curve defined over a number field.* Preliminary report.

Let p be a prime, let $n \geq 1$, let L be a number field, let E/L be an elliptic curve, and let $R \in E[p^n]$ be a torsion point of exact order p^n . In this talk we discuss the properties of $L(R)$, the field of definition of R . In particular, we give explicit lower bounds on the degree $[L(R) : L]$ in terms of the degrees of the isogenies of E/L and the divisibility properties of the ramification index of $L(R)/L$ at primes above a fixed prime \wp over p . (Received February 08, 2013)

1088-11-204 **Domenico Aiello*** (aiello@math.umass.edu), Department of Mathematics and Statistics, Lederle Graduate Research Tower, University of Massachusetts, Amherst, MA 01003-9305. *Galois Theory of Iterated Morphisms on Reducible Elliptic Curves.* Preliminary report.

Let F be a number field and let A be an abelian algebraic group defined over F . For a prime ℓ and a point $\alpha \in A(F)$, the tower of extensions $F([\ell^n]^{-1}(\alpha))$ contains all of the ℓ -power torsion points of A along with a Kummer-type extension. The action of the absolute Galois group, $G_{\overline{\mathbb{Q}}/F}$ on this tower encodes information regarding the density of primes \mathcal{P} in the ring of integers of F for which the order of $\alpha \bmod \mathcal{P}$ is prime to ℓ . For $A = E$ an elliptic curve, Jones and Rouse have determined necessary and sufficient conditions for the Galois action on the tower $F([\ell^n]^{-1}(\alpha))$ to be as large as possible and under these conditions the associated density has been computed. In this talk, we will consider elliptic curves for which the Galois action is not as large as possible. In particular, we will study the Galois theory of the tower of extensions corresponding to a reducible elliptic curve E/\mathbb{Q} with an ℓ -torsion point defined over \mathbb{Q} and calculate the encoded density. (Received February 12, 2013)

1088-11-205 **Rafe Jones and Michelle Manes*** (mmanes@math.hawaii.edu), University of Hawaii, Department of Mathematics, 2565 McCarthy Mall, Keller 401A, Honolulu, HI 96822.
Discriminants and Galois groups for iterated rational functions.

Let f be a rational function of degree two defined over a number field K . In this talk we consider the extensions K_n obtained by adjoining the set $f^{-n}(0)$ to K , with a special interest in computing the Galois group of K_n/K . We show that the critical orbits of f determine the discriminants of the K_n , and these in turn can sometimes be used to show $\text{Gal}(K_n/K)$ is as large as possible. We apply the results to give the first non-polynomial example of a function with $\text{Gal}(K_n/K)$ as large as possible, and we suggest a one-parameter family of rational functions for further investigation. (Received February 11, 2013)

1088-11-207 **Jacob Tsimerman***, 238 Columbia St., APT 2W, Cambridge, MA 02139. *The Generic Abelian Variety over \mathbb{Q} is not Isogenous to a Jacobian.*

We discuss an old question of Katz and Oort, asking whether there exists an Abelian Variety over the rationals not Isogenous to any Jacobian. We show that, in a precise sense, most Abelian varieties satisfy the criterion. Our method combines a recent result of D.Zywina regarding the Monodromy action on torsion of Abelian Varieties in a family, with an Equidistribution result for Hecke operators. (Received February 11, 2013)

1088-11-209 **David Geraghty*** (geraghty@math.princeton.edu). *Cohomology growth and modularity lifting.*

I will discuss a modularity lifting theorem for n -dimensional representations of the Galois group of an arbitrary number field. The result is established by showing that one has sufficient growth of cohomology in a Taylor-Wiles system. The result is conditional on the existence of certain Galois representations and on a certain cohomology vanishing theorem. This is a joint work with Frank Calegari. (Received February 11, 2013)

1088-11-216 **Robert Pollack*** (rpollack@bu.edu), 111 Cummington Mall, Boston, MA 02155, and **Evan Dummit, Marton Hablicsek, Robert Harron, Lalit Jain and Daniel Ross.**
Families of overconvergent modular symbols.

Overconvergent modular symbols form an infinite-dimensional Banach space which contains all systems of Hecke-eigenvalues of overconvergent modular forms as well as the p -adic L -functions attached to these forms. In a previous joint work with Glenn Stevens, we gave an efficient algorithm which computes the overconvergent modular symbol attached to a classical modular form, and in particular, gave an efficient algorithm for computing p -adic L -functions. (These algorithms can also be used to compute Stark-Heegner points on elliptic curves.)

In this talk, we seek to generalize these algorithms to families of overconvergent modular symbols. Such a generalization would, for example, allow us to compute families of Hecke-eigenvalues, two-variable p -adic L -functions, as well as the Lambda-structure of Hida (Hecke) algebras. (Received February 11, 2013)

1088-11-236 **Rachel Pries*** (pries@math.colostate.edu) and **Colin Weir.** *Dynamics associated with Jacobians of Hermitian curves.*

The dynamics of the multiplication-by-two map on $\mathbb{Z}/(2^n + 1)$ play a surprising role in recent work of myself and Colin Weir about Jacobians of Hermitian curves. For $q = p^n$, the Hermitian curve $X_q : y^q + y = x^{q+1}$ has special arithmetic significance. It is maximal over \mathbb{F}_{q^2} which implies that its Jacobian J_q is supersingular, namely J_q is isogenous to a product of supersingular elliptic curves. Moreover, X_q is the Deligne-Lusztig variety of dimension 1 associated with the group $\text{PGU}(3, q)$. We find new results about the decomposition of J_q up to isomorphism by determining its Ekedahl-Oort type (equivalently, its Dieudonné module or the module structure of its de Rham cohomology). There are very few curves for which this structure has been analyzed. We prove that the indecomposable factors in the Ekedahl-Oort type are determined by the orbit structure of the multiplication-by-two map; in particular, while their multiplicities depend on p , their structures do not. (Received February 11, 2013)

1088-11-240 **Mark McConnell*** (mmcconne117704@yahoo.com). *Mod 2 Cohomology for $GL(4)$ and Galois Representations.* Preliminary report.

In a series of papers, Ash, Gunnells and McConnell have studied cohomology groups for congruence subgroups Γ of $\text{SL}(4, \mathbb{Z})$, and have verified experimentally that Hecke eigenclasses for these cohomology groups appear to have attached Galois representations. We extend these computations to find the mod 2 homology in degree 1 of a congruence subgroup Γ with coefficients in the sharply complex, along with the action of the Hecke algebra. This homology group is closely related to the cohomology of Γ with \mathbb{F}_2 coefficients in the top cuspidal degree. These computations require a modification of the algorithm to compute the action of the Hecke operators, whose previous versions required division by 2. We verify experimentally that every mod 2 Hecke eigenclass found

appears to have an attached Galois representation. The Galois representations we find come from Dirichlet characters, or from classical cusp forms in characteristic zero of weights 2 or 3. (Received February 11, 2013)

1088-11-242 **Matthew Greenberg*** (mgreenbe@ucalgary.ca), Department of Mathematics and Statistics, University of Calgary, 2500 University Drive, Calgary, Alberta T2N1N4, Canada. *Eisenstein cocycles on $GL_n(\mathbb{Q})$.*

In this talk on joint work with Pierre Charollois and Samit Dasgupta, I will discuss a construction of an “Eisenstein” $(n-1)$ -cocycle on $GL_n(\mathbb{Q})$ based on Shintani’s method. After indicating some of its arithmetic applications, I will describe our cocycle’s relation to other Eisenstein cocycles appearing in the literature. (Received February 11, 2013)

1088-11-249 **Jeffrey D Achter*** (achter@math.colostate.edu), Department of Mathematics, Colorado State University, Fort Collins, CO 805231874. *The distribution of torsion group schemes among abelian varieties over finite fields.*

Consider function fields over finite fields of characteristic p . A key step in counting abelian unramified ℓ -extensions of such fields is interpreting the question as one about the distribution of forms of \mathbb{Z}/ℓ among the ℓ -torsion group schemes of Jacobians. The situation for p -torsion is much more intricate. In this talk, I’ll discuss the problem of counting and classifying the group schemes $X[p^n]$ as X ranges over $\mathcal{A}_{g,1}(\mathbb{F}_{p^e})$. (Received February 11, 2013)

1088-11-254 **Michael R. Bush*** (bushm@wlu.edu), Dept. of Mathematics, Washington and Lee University, Lexington, VA 24450, and **Daniel C. Mayer**. *Finding p -class towers of length 3*. Preliminary report.

The Hilbert p -class tower of a number field K is the chain of extensions obtained by taking the maximal unramified abelian p -extension of K and then iterating. Due to a result of Golod and Shafarevich, it’s known that such towers can be infinite and one can easily give explicit examples. On the finite side of the picture, it’s hard to find examples in which the tower has any appreciable length. In this talk, I’ll describe some examples of quadratic fields with 3-class towers of length 3 and how they were found using properties of the associated Galois groups. These are the first examples of finite Hilbert p -class towers of length greater than 2 when p is an odd prime. (Received February 12, 2013)

1088-11-282 **Dmitry Kleinbock*** (kleinboc@brandeis.edu), Department of Mathematics, Brandeis University, Waltham, MA 02454, and **Barak Weiss**. *More about values of binary quadratic forms at integer points*. Preliminary report.

It is well known that the conclusion of the Oppenheim conjecture fails in dimension two, that is, there are plenty of indefinite quadratic forms Q in two variables whose values at integer points are not dense. We strengthen this to the following extent: for a given countable set C of real numbers, the set of Q s such that the closure of $Q(\mathbb{Z}^2)$ is disjoint from C has Hausdorff dimension 3.

The proof consists of reducing the desired number-theoretic statement to a property of geodesic trajectories on the space of lattices in \mathbb{R}^2 . The dynamical statement is valid in a bigger generality of partially hyperbolic actions on homogeneous spaces, with some applications beyond binary quadratic forms. (Received February 12, 2013)

12 ► *Field theory and polynomials*

1088-12-29 **Eric Kimball*** (ekimball@bates.edu). *Frobenius Pseudoprimes and a Cubic Primality Test*. Preliminary report.

An integer, n , is called a Frobenius probable prime with respect to a polynomial when it passes the Frobenius probable prime test. Composite integers that are Frobenius probable primes are called Frobenius pseudoprimes. Jon Grantham developed and analyzed a Frobenius probable prime test with quadratic polynomials. Using the Chinese Remainder Theorem and Frobenius automorphisms, we were able to extend Grantham’s results to some cubic polynomials. This case is computationally similar but more efficient than the quadratic case. (Received January 14, 2013)

1088-12-189 **Lindsay N. Childs*** (lchilds@albany.edu). *Hopf Galois structures on Galois extensions of fields of degree mp* .

Let Γ be a group of order mp where p is prime and $m < p$. T. Kohl has shown that regular subgroups of $\text{Perm}(\Gamma)$ normalized by the image $\lambda(\Gamma)$ of the left regular representation λ lie in the normalizer in $\text{Perm}(\Gamma)$ of the p -Sylow subgroup of $\lambda(\Gamma)$. These regular subgroups correspond by Galois descent to Hopf Galois structures

on a Galois extension of fields with Galois group Γ . We apply Kohl's work to determine the regular subgroups isomorphic to M where Γ and M are semidirect products $C_p \rtimes C_m$ of cyclic groups, and connect those regular subgroups with previous work on Hopf Galois structures obtained by other methods. (Received February 10, 2013)

1088-12-269 **Nelly Fazio** and **Rosario Gennaro*** (rosario@cs.ccny.cuny.edu), Center for Algorithms and Interactive, Scientific Software – CCNY, 160 Convent Ave – NAC 8/209, New York, NY 10031, and **Milinda Pereira** and **William E. Skeith**. *Diffie-Hellman Problems with Deterministic Hard-Core Bits*.

One of the long-standing open problems in cryptography is the security of individual bits of the secret value that results from a Diffie-Hellman key exchange. As of today no deterministic predicate of this secret value can be proven to be unpredictable. In this paper, we focus on the Diffie-Hellman problem over two specific platform groups: the group of points over elliptic curves and the multiplicative group of the quadratic extensions field over \mathbb{F}_p . We solve this question by showing the first deterministic hard-core predicates for the Diffie-Hellman problem over those groups. Extending the Fourier-analysis and list decoding techniques by Akavia et al. and Duc et al. we show that under the assumption that computing the secret Diffie-Hellman value is hard in these group, then any individual bit of such secret value is unpredictable. (Received February 12, 2013)

13 ► Commutative rings and algebras

1088-13-83 **Mats Boij*** (boij@kth.se), Department of mathematics, KTH - Royal Institute of Technology, 100 44 Stockholm, Sweden. *Parameter spaces of graded modules*. Preliminary report.

Parameter spaces of graded modules with a given Hilbert function H can be defined in a similar way as the strata of the Hilbert scheme parametrizing subschemes of projective spaces with a given Hilbert function.

I will discuss results on how the number of components can grow with n as we take higher and higher multiples nH of a given Hilbert function H . Moreover, I will discuss what can happen when we fix the h -vector of a Cohen-Macaulay module and study the parameter spaces of modules of various dimensions, all with the same h -vector. (Received February 04, 2013)

1088-13-169 **Riccardo Biagioli** and **Sara Faridi*** (faridi@mathstat.dal.ca), Department of Mathematics & Statistics, Dalhousie University, 6316 Coburg Rd. PO BOX 15000, Halifax, NS B3H 4R2, Canada, and **Mercedes Rosas**. *Ideals of conjugacy classes of nilpotent matrices*.

We survey ideals associated to conjugacy classes of nilpotent matrices. Using partitions of the size of the matrix, one can index these ideals. In this talk we review these structures, and study generating sets and properties of these ideals based on the Young diagrams of the partitions. We also discuss resolutions of these ideals based on the shape of the Young diagrams associated to the corresponding partitions. (Received February 09, 2013)

14 ► Algebraic geometry

1088-14-62 **Eugene Gorsky*** (egorsky@math.sunysb.edu), Department of Mathematics, Stony Brook University, 100 Nicolls Road, Stony Brook, NY 11794. *Cherednik algebras, Hilbert schemes and knot invariants*.

The work of I. Gordon and T. Stafford highlighted connections between the representation theory of rational Cherednik algebras and the geometry of the Hilbert schemes of points on \mathbb{C}^2 . In particular, I. Gordon related certain finite-dimensional representations of these algebras to the spaces of diagonal coinvariants defined by A. Garsia and M. Haiman, and to the spaces of sections of certain sheaves on the Hilbert scheme.

I will describe a conjectural generalization of these results, matching other finite-dimensional representations of rational Cherednik algebras with sheaves on the Hilbert scheme recently constructed by A. Negut. The characters of these representations turn out to be related to certain invariants of torus knots. I will also explain connections to the recent work of M. Aganagic, I. Cherednik and S. Shakirov on refined knot invariants. (Received January 31, 2013)

1088-14-64 **Arend Bayer** (arend.bayer@ed.ac.uk), School of Mathematics, Mayfield Road, James Clerk Maxwell Building, Edinburgh, EH9 3JZ, United Kingdom, and **Emanuele Macri*** (macri.6@osu.edu), Department of Mathematics, 231 W 18th Ave, Columbus, OH 43210. *Birational geometry of moduli spaces of sheaves on K3 surfaces.*

We report on recent joint work on how one can use wall-crossing techniques to study the birational geometry of a moduli space M of Gieseker-stable sheaves on a K3 surface X . In particular: 1. We will give a "modular interpretation" for all minimal models of M . 2. We will describe the nef cone, the movable cone, and the effective cone of M in terms of the algebraic Mukai lattice of X . 3. We will establish the so called Tyurin/Bogomolov/Hassett-Tschinkel/Huybrechts/Sawon Conjecture on the existence of Lagrangian fibrations on M . (Received January 31, 2013)

1088-14-89 **Mark E Huibregtse*** (mhuibreg@skidmore.edu), Dept. of Mathematics & Computer Science, Skidmore College, Saratoga Springs, NY 12866. *Title: A generalization of Iarrobino and Emsalem's construction of elementary components of the Hilbert scheme of points.* Preliminary report.

Let K be an algebraically closed field, and let H denote the Hilbert scheme of μ points of \mathbb{A}_K^r . An **elementary component** X of H is an irreducible component such that every K -point $x \in X$ represents a length- μ closed subscheme $Z_x \subseteq \mathbb{A}_K^n$ that is supported at one point. In [*Some Zero-Dimensional Generic Singularities: Finite Algebras Having Small Tangent Space*, Compos. Math. 36 (1978), 145-188], Iarrobino and Emsalem gave the first examples of elementary components; in their examples, the subschemes $Z_x = \text{Spec}(K[x_1, \dots, x_n]/I_x)$ with I_x homogeneous (up to a change of coordinates corresponding to a translation of \mathbb{A}_K^r). We generalize their construction to obtain elementary components for which the ideals I_x are not homogeneous. (Received February 04, 2013)

1088-14-93 **David Jensen***, djensen@math.sunysb.edu. *Stability of Second Hilbert Points of Canonical Curves.*

The goal of the Hassett-Keel program is to describe each of the log canonical models of the moduli space of curves as a moduli space in its own right. In joint work with Maksym Fedorchuk, we study the model obtained via GIT for second Hilbert points of canonical curves. We provide an explicit criterion for a smooth curve to be semistable, and also identify a vast array of semistable singular curves. (Received February 04, 2013)

1088-14-110 **Melody Chan*** (mtchan@math.harvard.edu). *Combinatorics of the tropical moduli space of curves.*

A tropical curve is a metric graph marked with integer vertex weights obtained as a metrized dual graph of a semistable model of a curve over a valued field. We will review the construction tropical moduli space $M_{g,n}^{trop}$ of genus g tropical curves with n marked points and report on some combinatorial properties of these spaces. (Received February 05, 2013)

1088-14-126 **Matthew Woolf*** (mwoolf@math.harvard.edu). *Effective Divisors on the Moduli Space of One-dimensional Sheaves on the Projective Plane.* Preliminary report.

The moduli spaces of pure one-dimensional semistable sheaves on the plane are natural compactifications of the relative Picard varieties of universal smooth plane curves. In this talk, we will calculate the cone of effective divisors for these moduli spaces in a number of cases. (Received February 06, 2013)

1088-14-133 **Melissa Haire*** (melissa.haire@gordon.edu). *Fermat curves in the plane.*

A plane algebraic curve is a curve defined implicitly by a relation of the form $f(x, y) = 0$, where $f(x, y)$ is a polynomial in x and y . A curve is said to be rational if it can be parametrized by rational functions $x(t), y(t)$. In this talk we will discuss necessary conditions for a rational curve to be defined on the complement of high degree algebraic Fermat curves. (Received February 07, 2013)

1088-14-145 **Alexei Oblomkov*** (oblomkov@math.umass.edu), 31 B Lyman Rd, Northampton, MA 01060, and **Zhiwei Yun**. *Cohomology rings of the elliptic Affine Springer Fibers in type A.*

Joint work with Zhiwei Yun. The Affine Springer Fibers from the title are homeomorphic to the compactified Jacobians $JC_{m,n}$ of curves $x^m = y^n$, $(m, n) = 1$. In elementary terms $JC_{m,n}$ is the space of subspaces $L \subset \mathbb{C}[[t]]$ of codimension $(m-1)(n-1)$ that are preserved by multiplication on t^m and t^n . Together with Zhiwei Yun we described an action of the spherical rational Cherednik algebra $eH_{m/n}(S_n)e$ on $H^*(JC_{m,n})$ and the ring structure of the cohomology. The ring structure is very similar to the ring structure of the finite dimensional Grassmanians, and in my talk I will discuss this analogy and connections with q, t Catalan numbers. (Received February 07, 2013)

1088-14-160 **Aaron Pixton*** (apixton@math.princeton.edu). *The tautological ring of the moduli space of stable curves.*

The tautological ring of the moduli space of stable curves is a subring of the Chow ring consisting of the cycles that arise naturally in geometry through forgetful and gluing morphisms. After summarizing what is known about this ring on the interior of the moduli space, I will sketch a conjectural description of the full tautological ring as the quotient of a certain "strata algebra" by an explicit set of relations, and then I will briefly discuss the evidence for and possible implications of this conjecture. Part of this talk presents joint work with R. Pandharipande and D. Zvonkine. (Received February 08, 2013)

1088-14-164 **Ana-Maria Castravet*** (castravet.1@osu.edu), Ohio State University, 231 W 18th Avenue, Math Tower, Columbus, OH 43210, and **Jenia Tevelev**, University of Massachusetts Amherst, Amherst, MA. *Rigid curves on moduli spaces of stable rational curves and arithmetic breaks.*

The Mori cone of curves of the Grothendieck-Knudsen moduli space of stable rational curves with n markings, is conjecturally generated by the one-dimensional strata (the so-called F-curves). A result of Keel and McKernan states that a hypothetical counterexample must come from rigid curves that intersect the interior. In this talk I will show several ways of constructing rigid curves. In all the examples a reduction mod p argument shows that the classes of the rigid curves that we construct can be decomposed as sums of F-curves. (Received February 08, 2013)

1088-14-170 **Yaim Cooper*** (yaim@math.princeton.edu) and **Aleksey Zinger**. *Relating Gromov-Witten and Stable Quotient Invariants.*

In this talk we will discuss recent results comparing stable quotients and stable maps. We will compare the geometry of the moduli spaces themselves, and also compare the invariants they can be used to define. Specifically, in genus 1 we compare the geometries of $\bar{M}_1(P^r, d)$ and $\bar{Q}_1(P^r, d)$, and in genus 0 we compare the stable quotient invariants of Fano and Calabi-Yau complete intersections in P^r to the corresponding Gromov-Witten invariants. The latter represents joint work with A. Zinger. (Received February 09, 2013)

1088-14-171 **David J Swinarski*** (dswinarski@fordham.edu), 113 W 60th St Room 813, New York, NY 10023, and **Anand Deopurkar** and **Maksym Fedorchuk**. *GIT stability of syzygies of canonical ribbons.* Preliminary report.

I will discuss work in progress with Anand Deopurkar and Maksym Fedorchuk. A balanced ribbon is a particular nonreduced curve of odd genus with a \mathbb{G}_m action. In 2011, Alper, Fedorchuk, and Smyth proved that the point in the Hilbert scheme corresponding to this curve under its canonical embedding is GIT stable with respect to a number of linearizations. We explore GIT stability of the point in a suitable Grassmannian corresponding to the vector space of syzygies of this curve. (Received February 09, 2013)

1088-14-175 **Julie Rana*** (rana@math.umass.edu). *Boundary divisors in the moduli space of stable quintic surfaces.* Preliminary report.

The moduli space of minimal surfaces of general type with fixed invariants admits a well-known compactification, the moduli space of stable surfaces, introduced by Kollár-Shepherd-Barron and Alexeev. Here, stable surfaces are connected projective surfaces with ample canonical class and semi log canonical singularities. There are two natural loci in this moduli space which are Cartier divisors if certain conditions are met. One of these corresponds to normal surfaces which have a unique Wahl singularity. A different set of expected boundary divisors corresponds to surfaces with orbifold normal crossings with some conditions on the orbifold normal bundle. We discuss these surfaces in the case of stable quintics. (Received February 09, 2013)

1088-14-177 **Yu-jong Tzeng*** (ytzeng@math.harvard.edu), 1 Oxford Street, Cambridge, MA 02138. *Enumeration of singular curves with tangency conditions.*

How many nodal degree d plane curves are tangent to a given line? The celebrated Caporaso-Harris recursion formula gives a complete answer for any number of nodes, degrees, and all possible tangency conditions. In this talk, I will report my recent work on the generalization of the above problem to count singular curves with given tangency condition to a fixed smooth divisor on all smooth surfaces. I will show how Hilbert schemes of points on surfaces can be used to identify each singularity type. (Received February 09, 2013)

1088-14-179 **Dmitry Zakharov*** (dvzakharov@gmail.com) and **Samuel Grushevsky**. *The Abel-Jacobi map and cycles on the moduli space of curves.*

Given an algebraic curve C with marked points p_1, \dots, p_n and integer weights d_1, \dots, d_n , we consider the line bundle $\mathcal{O}_C(\sum d_i p_i)$. This defines an Abel-Jacobi map from $\mathcal{M}_{g,n}$ to the universal Jacobian Jac_g , and pulling

back classes from Jac_g we get relations in the tautological ring of $\mathcal{M}_{g,n}$. I will talk about several results obtained in this way, including the calculation of the double ramification cycle on $\mathcal{M}_{g,n}^{ct}$, the extension of the double ramification cycle to curves admitting one non-separating node, and some calculations about Faber's conjectures on the tautological rings of $\mathcal{M}_{g,n}$ and $\mathcal{M}_{g,n}^{ct}$. (Received February 09, 2013)

1088-14-197 **Yuri Berest*** (berest@math.cornell.edu), Department of Mathematics, Cornell University, Ithaca, NY 14853-4201. *Calogero-Moser spaces, differential operators on curves and ind-algebraic groups.*

Commuting matrices have natural infinite-dimensional analogues: commuting differential operators. The problem of classifying (maximal) commutative algebras of differential operators has a long history with many interesting connections to different areas of mathematics. In the first part of the talk, we will review some of these connections and give some examples. Then we will focus on the (better understood) case of differential operators on curves. In the case of rational curves, we will see that the problem of classifying commuting differential operators leads to basic questions about the structure of (infinite-dimensional) algebraic subgroups of the affine Cremona group. We will end by presenting recent results in this direction (on classification of Borel subgroups) obtained in joint work with A. Eshmatov and F. Eshmatov. (Received February 10, 2013)

1088-14-200 **Alimjon Eshmatov*** (aeshmato@uwo.ca), Department of Mathematics, The University of Western Ontario, London, ON N6A 5B7, Canada, **Yuri Berest** (berest@math.cornell.edu), Ithaca, NY 14850, and **Farkhod Eshmatov** (faeshmat@indiana.edu), Bloomington, IN. *Dixmier subgroups of the affine Cremona group.*

In this talk, we will discuss a class of infinite-dimensional (ind-algebraic) groups G_n closely related to the group of polynomial automorphisms of the affine plane. These groups originate from the theory of integrable systems and can be realized geometrically as automorphism groups of rings of differential operators on singular spectral curves. By analogy with affine algebraic groups, we define the notion of a Borel subgroup and prove an infinite-dimensional version of a classical theorem of R. Steinberg characterizing these subgroups in G_n in abstract terms. Then we show that up to conjugation there are exactly $p(n)$, where $p(n)$ is the number of partitions of n , Borel subgroups of G_n . (Joint work with Y. Berest and F. Eshmatov) (Received February 10, 2013)

1088-14-203 **Bart Van Steirteghem*** (bartvs@mec.cuny.edu), 1650 Bedford Avenue, Brooklyn, NY 11225. *The invariant Hilbert scheme of V. Alexeev and M. Brion: a survey.*

In 2003 V. Alexeev and M. Brion introduced the invariant Hilbert scheme as a new tool for the classification problem of affine algebraic varieties equipped with an action of a complex reductive group G . It is a common generalization of the G -Hilbert scheme of Y. Ito and I. Nakamura (where G is finite) and of the multigraded Hilbert scheme of M. Haiman and B. Sturmfels (where G is diagonalizable). Loosely speaking, it brings geometry to the following natural question: to what extent does the G -module structure of the coordinate ring of an affine G -variety determine its algebra structure?

In this talk I will present the definition and basic properties of the invariant Hilbert scheme and discuss several examples due to S. Jansou, N. Ressayre, J. Budniger, T. Becker and R. Terpereau. I will then give an overview of the applications of the invariant Hilbert scheme to the classification of spherical varieties, including work by P. Bravi, S. Cupit-Foutou, S. Papadakis, G. Pezzini and me. (Received February 11, 2013)

1088-14-231 **Mikhail Mazin*** (mmazin@math.sunysb.edu), Institute for Mathematical Sciences, Stony Brook University, Stony Brook, NY 11794-3660. *Hilbert Schemes and Jacobi Factors of Plane Curve Singularities.*

Hilbert schemes and Jacobi factors of quasihomogeneous plane curve singularities can be decomposed into complex affine cells enumerated by Young diagrams. Dimensions of cells can be computed combinatorially in terms of the Young diagrams. Resulting combinatorial theory turns out to be related to a number of different subjects: Garsia-Haiman q,t -Catalan numbers and their generalizations, partitional statistics arising from Ellingsrud-Stromme computation of the character of the tangent space to the Hilbert scheme of the plane at a fixed point, combinatorics of affine symmetric groups, etc.

This talk is mostly based on a joint work with Eugene Gorsky. (Received February 11, 2013)

1088-14-251 **Mathias Lederer** and **Jenna Rajchgot*** (rajchgot@umich.edu). *Doubly universal Gröbner bases.*

A universal Gröbner basis of an ideal in a polynomial ring is a finite set of polynomials which is a (non-reduced, non-minimal) Gröbner basis for every monomial order. In this talk, I'll explain a way to generalize this notion from ideals in a polynomial ring to an ideal sheaf defining the universal family over a Hilbert scheme, and I'll

explicitly describe the form of such a universal Gröbner basis. I'll end by discussing a few applications, which should serve as motivation for the construction.

This is joint work with Mathias Lederer. (Received February 11, 2013)

1088-14-264 **Mathias Lederer*** (mlederer@math.uni-bielefeld.de). *Poincaré duality in the Hilbert scheme of points in the plane.*

We will revisit Ellingsrud and Strømme's Białynicki-Birula decomposition of the Hilbert scheme of points in the projective plane. This is a cell decomposition indexed by triples of standard sets. In particular, the cohomology ring is a free module whose basis is given by triples of standard sets. We will give a combinatorial description of Poincaré duality in this Hilbert scheme. Our key tool consists of two dual partial orderings on the set of standard sets of a given cardinality n . (Received February 12, 2013)

16 ► Associative rings and algebras

1088-16-13 **Uma Iyer** (uma.iyer@bcc.cuny.edu), Bronx Community College, 2155 University Avenue, Bronx, New York, NY 10453, and **Earl J. Taft*** (etaft@math.rutgers.edu), Department of Mathematics, Rutgers University, Piscataway, NJ 08854. *The search for a left quantum universal enveloping algebra.* Preliminary report.

S. Rodriguez-Romo and E. J. Taft constructed a variant H' of $H = \text{quantum SL}(2)$ with a left antipode S which is not a right antipode [J. Algebra 286 (2005), 154-160]. H' is given by 4 generators X_{ij} , $i, j = 1, 2$ and 4 relations-2 are q -commutation relations on the columns of $X = (X_{ij})$ and 2 equate two versions of the quantum determinant of X to 1. H is a Hopf algebra homomorphic image of H' . Taking continuous duals, H^0 embeds in H'^0 . The quantum universal enveloping algebra of $\mathfrak{sl}(2)$ embeds in H^0 . In principle, H'^0 should be a left (but not right) Hopf algebra with left antipode S^0 . One would have to show an element of H'^0 on which the right antipode condition for S^0 fails. While much is known about H^0 , we are still unable to find generators and relations for H'^0 . This is a report on the search for such generators and relations. (Received November 20, 2012)

1088-16-14 **Akira Masuoka*** (akira@math.tsukuba.ac.jp), Tsukuba, Ibaraki 305-8571, Japan. *Hopf algebraic techniques applied to super algebraic groups.* Preliminary report.

I will report my recent results on super algebraic groups, joint with Alexandr Zubkov, Taiki Shibata and Craig Pastro, emphasizing the Hopf algebraic techniques applied. The results will include basic results on the quotient sheaf G/H (joint with Zubkov), a category equivalence between the Harish-Chandra pairs and the super algebraic groups (by myself), a Hopf algebraic construction of the super Chevalley groups over \mathbb{Z} (joint with Shibata), and some results on integrals (joint with Patro). (Received February 04, 2013)

1088-16-19 **Uma N Iyer*** (uma.iyer@bcc.cuny.edu), Dept. of Mathematics & Computer Science, CP315, BCC, University Avenue & W 181 St, Bronx, NY 10453, **David A Jordan** (d.a.jordan@sheffield.ac.uk), Department of Pure Mathematics, University of Sheffield, Hicks Building, Sheffield, SR 7RH, United Kingdom, and **Timothy C McCune** (tcmccune@yahoo.com), 3 East Mill Drive, #1E, Great Neck, NY 11021. *Noetherian Algebras of Quantum Differential Operators.*

We follow the definition of quantum differential operators on graded algebras, given by Lunts and Rosenberg. We establish the algebra of quantum differential operators on the quantum torus and the quantum Grassmann algebra and study the properties of these algebras. In particular, we study the Noetherian properties of these algebras. (Received December 15, 2012)

1088-16-25 **irawati irawati irawati*** (irawati@math.itb.ac.id), Algebra research group., Institut Teknologi Bandung, Jalan Ganesha no 10, Bandung, 40227, Indonesia. *The Application of the connectivity between uniserial module over an Artinian ring with its Jacobson Radical.*

We first look at the connection between uniserial module over Artinian ring with its Jacobson Radical. Then we use this result to get a characterization of a uniserial Artinian ring. (Received January 04, 2013)

1088-16-115 **Florin Felix Nichita*** (florin.nichita@imar.ro), Institute of Mathematics "Simion Stoilow", of the Romanian Academy, Bucharest, Romania. *Hopf algebras, Yang-Baxter equations and related structures.*

This talk will be a survey on recent results on Hopf algebras, Yang-Baxter equations, entwining structures and corings. Many of these results have been published in a Special Issue of the journal "Axioms".

Also, a new concept will be analyzed. Semi-entwining structures are concepts simpler than entwining structures, yet they have interesting applications in constructing intertwining operators and braided algebras, lifting functors, finding solutions for Yang-Baxter systems, etc. (Received February 05, 2013)

1088-16-155 **Alessandro Ardizzoni*** (alessandro.ardizzoni@unito.it), Università di Torino, Dipartimento di Matematica "Giuseppe Peano", Via Carlo Alberto 10, I-10123 Torino, Italy. *Quasi-bialgebra Structures and Torsion-free Abelian Groups.*

We describe all the quasi-bialgebra structures of a group algebra over a torsion-free abelian group. They all come out to be triangular in a unique way. Moreover, up to an isomorphism, these quasi-bialgebra structures produce only one (braided) monoidal structure on the category of their representations. Applying these results to the algebra of Laurent polynomials, we recover two braided monoidal categories introduced by S. Caenepeel and I. Goyvaerts in connection with Hom-structures (Lie algebras, algebras, coalgebras, Hopf algebras).

This is based on a joint work with Daniel Bulacu (Univ. of Bucharest, Romania) and Claudia Menini (Univ. of Ferrara, Italy). (Received February 08, 2013)

1088-16-183 **Margaret Beattie*** (mbeattie@mta.ca) and **Gaston Andres Garcia.** *Classifying Hopf algebras of dimension $8p$.*

The classification of all Hopf algebras over \mathbb{C} for a class of finite dimensions has only been completed for a few cases, for example, if p, q are primes, for p (Zhu 1994), p^2 (Ng 2002), $2p$ (Ng 2005), $2p^2$ (Hilgemann & Ng 2009), and for pq with $2 < p < q \leq 4p + 11$ (Ng 2008). As well, there are partial results for dimension $4p$ (Cheng & Ng 2011), p^3 (García 2005, Beattie & García 2013).

We say that a Hopf algebra H has type (r, s) if the grouplikes in H have order r and the grouplikes in H^* have order s . In this talk we will consider Hopf algebras of dimension $8p$ and prove:

Theorem *For H a Hopf algebra of dimension $8p$ over \mathbb{C} which is not semisimple, not pointed and H^* is not pointed, then H is of type (r, s) where either r, s are both powers of 2, or $r = 2p$ and s is 2 or 4.*

Finally we'll consider dimension 24, the smallest dimension for which the classification is still incomplete. Here we can prove that H always has a grouplike element of order 2 and so the classification is improved.

This is joint work with G.A.García. (Received February 10, 2013)

1088-16-184 **Leonid Krop*** (lkrop@condor.depaul.edu), 2320 N. Kenmore, 2320 N. Kenmore, Chicago, IL 60614. *Simple Modules for Pointed Hopf Algebras.*

We present a method for constructing all simple modules for a class of pointed finite-dimensional Hopf algebras H . Let $G = G(H)$ be the group of grouplikes of H and Z be the subgroup of its central elements. Let us write \hat{Z} for the set of characters of Z . There is a standard mapping $\pi : \text{Irr } H \rightarrow \hat{Z}$. We describe the fibers $F_\lambda = \pi^{-1}(\lambda)$, $\lambda \in \hat{Z}$ under varying assumptions on H . (Received February 10, 2013)

1088-16-190 **Jeffrey Bergen*** (jbergen@depaul.edu) and **Piotr Grzeszczuk** (piotrgr@pb.edu.pl). *Locally Nilpotent Skew Derivations.*

We examine the structure of rings R with locally nilpotent skew derivations δ . Of particular interest is the relationship between the structure of R and the subring of invariants R^δ . In a related work, we also obtain some results on the invariance of the nil and prime radicals under skew derivations. (Received February 10, 2013)

1088-16-191 **Yorck Sommerhäuser*** (sommerh@southalabama.edu), University of South Alabama, Department of Mathematics and Statistics, 411 University Blvd N, Mobile, AL 36688. *Semilinear Actions of General Linear Groups on Character Rings of Hopf Algebras.*

It has been shown by Y. Zhu and the speaker that the action of the modular group $\text{SL}(2, \mathbb{Z})$ on the character ring of a semisimple factorizable Hopf algebra factors over the reduced modular group $\text{SL}(2, \mathbb{Z}_N)$ of 2×2 -matrices with entries in the finite ring \mathbb{Z}_N of integers modulo N , where N is the exponent of the Hopf algebra, under the assumption that the base field has characteristic zero and that the value of an integral on the inverse Drinfel'd element differs from its value on the Drinfel'd element itself by at most a sign.

Here, the reduced modular group acts via linear maps. However, as we explain in the talk, this action can be extended to an action of the general linear group $\text{GL}(2, \mathbb{Z}_N)$ if one does not only consider linear maps, but also semilinear maps, where 'semilinear' means that the scalars are modified by the action of the Galois group $\text{Gal}(\mathbb{Q}_N/\mathbb{Q})$ of the cyclotomic field. This action of the general linear group also provides a better understanding of a certain Galois condition satisfied by the Drinfel'd element. The talk is based on a recent article (Adv. Math. 236 (2013), 158-223) written jointly with Y. Zhu. We present the results using modular data. (Received February 10, 2013)

1088-16-223 **Stefan Catoiu*** (scatoiu@condor.depaul.edu), Department of Mathematics, DePaul University, 2320 N. Kenmore Avenue, Chicago, IL 60614. *The algebra of \mathfrak{n} -invariants*. Preliminary report.

Let $\mathfrak{g} = \mathfrak{n}_- \oplus \mathfrak{h} \oplus \mathfrak{n}_+$ be a triangular decomposition of a finite dimensional semisimple Lie algebra \mathfrak{g} in characteristic zero. The adjoint action of \mathfrak{g} extends canonically to an action of the enveloping algebra $U = U(\mathfrak{g})$ on itself. In particular, $U(\mathfrak{n}_+)$ acts adjointly on U . The algebra of invariants $U^{\mathfrak{n}_+}$ can be described by generators and relations as a skew-polynomial algebra over the center Z of U . Since every ideal I of U is generated as an adjoint module by $I \cap U^{\mathfrak{n}_+}$, this leads to finding presentations by generators in $U(\mathfrak{n}_+)$ for the ideals of U . In the case of primitive ideals, this gives a better insight on the internal structure of the corresponding irreducible representations of U . Similar results hold in the quantum case. I will illustrate how this process works on low rank examples. The subject is related to Littleman's path bases in the classical case, and Kashiwara's crystal bases in the quantum case.

(Received February 11, 2013)

1088-16-225 **Sabin Cautis*** (scautis@math.columbia.edu), 3111 3rd Street #10, Santa Monica, CA 90405. *Triply graded coloured homology*.

We explain how to associate to any partition a triply graded link homology. In this setup, the original Khovanov-Rozansky triply graded link homology corresponds to the simplest partition containing only one box. Recently, similar homologies have been discussed by mathematical physicists using a physical description as spaces of open BPS states. (Received February 11, 2013)

1088-16-230 **Sorin Dascalescu*** (sdascal@fmi.unibuc.ro), Facultatea de Matematica si Informatica, Universitatea din Bucuresti, Str. Academiei 14, RO-010014 Bucharest, Romania, and **Miodrag C Iovanov** and **Constantin Nastasescu**. *Path subcoalgebras, finiteness properties and quantum groups*.

We study subcoalgebras of path coalgebras that are spanned by paths, called path subcoalgebras. We classify the left co-Frobenius path subcoalgebras, showing that they are direct sums of certain path subcoalgebras arising from the infinite line quiver or from cyclic quivers. We investigate which of the co-Frobenius path subcoalgebras can be endowed with Hopf algebra structures, in order to produce some quantum groups with non-zero integrals, and we classify all these structures over a field with primitive roots of unity of any order. (Received February 11, 2013)

1088-16-252 **William Chin*** (wchin@condor.depaul.edu), Dept. of Mathematical Sciences, DePaul University, Chicago, IL 60201, and **Daniel Simson**, Faculty of Mathematics and Computer Science, Nicolaus Copernicus University, Toruń, Poland. *Coxeter transformation and inverses of Cartan matrices for coalgebras*.

Let C be a coalgebra and consider the Grothendieck groups of the categories of socle-finite injective C -comodules. The main goal is to study the Coxeter transformation, and its dual, for a pointed coalgebra C with a certain finiteness condition, and to relate the action of these transformations on indecomposable finitely cogenerated C -comodules N with almost split sequences starting or ending with N . We show that if C is a pointed K-coalgebra such that the every vertex of the left Gabriel quiver of C has only finitely many neighbors, then for any indecomposable non-projective left C -comodule N of finite K-dimension, there exists a unique almost split sequence of finitely cogenerated left C -comodules ending at N . We also show that the dimension vector of the Auslander-Reiten translate given by the Coxeter transformation if C is hereditary, or more generally, if $\text{inj.dim } DN = 1$ and $\text{Hom}_C(C, DN) = 0$. (Received February 11, 2013)

17 ► Nonassociative rings and algebras

1088-17-150 **Claudia Menini*** (men@unife.it), Dipartimento di Matematica della Università, di Ferrara, via Machiavelli n. 35, I-44121 Ferrara, Italy. *QUASI-YETTER-DRINFELD DATA*. Preliminary report.

Let H be a dual quasi-bialgebra i.e. H is a type of bialgebra with the associativity condition relaxed by means of a 3-cocycle. We introduce the notion of quasi-Yetter-Drinfeld datum which encodes the properties for a one-dimensional vector space to be in the category YD of left-left Yetter-Drinfeld modules over H . Using such a datum, we construct a bialgebra R in YD . As in the non-quasi case, one can consider the bosonization B of R by H which is a dual quasi-bialgebra as well. This leads us to investigate the iteration of the process by considering

quasi-Yetter-Drinfeld data over B . This is part of a joint research with A. Ardizzoni and M. Beattie. (Received February 08, 2013)

1088-17-239 **Andrew Douglas*** (afdouglas@gmail.com), Department of Mathematics, City University of New York, NYCC, 300 Jay Street, Brooklyn, NY 11201, and **Delaram Kahrobaei** and **Joe Repka**. *Classification of embeddings of abelian extensions of D_n into E_{n+1} .*

An abelian extension of the special orthogonal Lie algebra D_n is a nonsemisimple Lie algebra $D_n \times V$, where V is a finite-dimensional representation of D_n , with the understanding that $[V, V] = 0$. We determine all abelian extensions of D_n that may be embedded into the exceptional Lie algebra E_{n+1} , $n = 5, 6$, and 7 . We then classify these embeddings, up to inner automorphism. As an application, we also consider the restrictions of irreducible representations of E_{n+1} to $D_n \times V$, and discuss which of these restrictions are or are not indecomposable. This is joint work with D. Kahrobaei and J. Repka. (Received February 11, 2013)

18 ► Category theory; homological algebra

1088-18-17 **Pavel Etingof*** (etingof@math.mit.edu), MIT, and **Shlomo Gelaki** (gelaki@math.technion.ac.il), Technion. *Reduction of tensor categories modulo primes.*

We study good (i.e., semisimple) reductions of semisimple rigid tensor categories modulo primes. A prime p is called good for a semisimple rigid tensor category C if such a reduction exists (otherwise, it is called bad). It is clear that a good prime must be relatively prime to the Müger squared norm $|V|^2$ of any simple object V of C . We show, using the Ito-Michler theorem in finite group theory, that for group-theoretical fusion categories, the converse is true. While the converse is false for general fusion categories, we obtain results about good and bad primes for many known fusion categories (e.g., for Verlinde categories). We also state some questions and conjectures regarding good and bad primes. (Received December 11, 2012)

1088-18-232 **Xiao-Gang Wen***, 31 Caroline Street North, Waterloo, Ontario N2L 2Y5. *The mathematical language to describe many-body quantum entanglement: fusion category theory and group cohomology theory.*

Some quantum phases of matter are described different patterns of quantum entanglement. The patterns of quantum entanglement are new phenomena that happen in nature. But what kind of mathematical language should we use to describe quantum entanglement. Here I would like to explain that fusion category theory and group cohomology theory are nature languages to describe various patterns of quantum entanglement. As a result, we can use fusion category theory and group cohomology theory to classify new quantum states of matter. (Received February 11, 2013)

1088-18-277 **Glenn Stevens*** (ghs@math.bu.edu), 111 Cummington Mall, Boston, MA 02446. *Slope Decompositions and the Eigenvariety Machine.*

Eigenvarieties have played an important role in the p -adic theory of automorphic forms and their global arithmetic properties, by providing a natural context for investigating families of galois representations, and p -adic L -functions. In this talk we present an axiomatic construction of cohomological eigenvarieties and discuss a conjecture of Eric Urban that predicts the dimension of these eigenvarieties in automorphic settings. Our starting point is the “eigenvariety machine” of Coleman-Mazur and Buzzard which produces eigenvarieties attached to orthonormalizable Banach modules with an action of the Hecke algebra. We extend this by constructing eigenvarieties associated to the arithmetic cohomology of orthonormalizable Banach modules and by giving a lower bound for their dimensions. These results are based on joint work with Avner Ash. (Received February 12, 2013)

20 ► Group theory and generalizations

1088-20-1 **Roman Bezrukavnikov*** (bezrukav@math.mit.edu). *Canonical bases and geometry.*

Geometric representation theory seeks to solve algebraic problems by relating them to algebraic geometry. For example, in many interesting cases the number of irreducible representations in a certain class turns out to equal the sum of Betti numbers of an appropriate algebraic variety, while the finer structure of representations is controlled by a particular basis in its cohomology space known as canonical basis. The original example of that picture is Kazhdan-Lusztig conjecture proved in 1980's; in the talk I will mention the tools used in that classical work and describe some concepts which entered the scene more recently allowing to generalize this approach to

new settings: algebro-geometric wall crossing, the use of loop spaces and geometric Langlands duality, quantum cohomology. (Received October 04, 2012)

1088-20-2 **Marston Conder*** (m.conder@auckland.ac.nz), Mathematics Department, University of Auckland, Private Bag 92019, Auckland, 1142, New Zealand. *Discrete objects with maximum possible symmetry.*

Symmetry is pervasive in both nature and human culture. The notion of chirality (or ‘handedness’) is similarly pervasive, but less well understood. In this lecture, I will talk about a number of situations involving discrete objects that have maximum possible symmetry in their class, or maximum possible rotational symmetry while being chiral. Examples include geometric solids, combinatorial graphs (networks), maps on surfaces, designs d’enfants, abstract polytopes, and even compact Riemann surfaces (from a certain perspective). I will describe some recent discoveries about such objects with maximum symmetry, illustrated by pictures as much as possible. (Received February 06, 2013)

1088-20-32 **Richard M Weiss*** (rweiss@tufts.edu), Tufts University, Department of Mathematics, 503 Boston Avenue, Medford, MA 02468, and **Holger P Petersson** and **Bernhard Mühlherr**. *Residues of Bruhat-Tits buildings.* Preliminary report.

We describe recent results about the structure of the residues of an affine building whose building at infinity is an exceptional Moufang polygon. (Received January 16, 2013)

1088-20-35 **Liljana Babinkostova** (liljanababinkostova@boisestate.edu), **Kevin Bombardier**, **Matthew Cole*** (mcole5@nd.edu), **Thomas Morrell** and **Cory Scott**. *AES-like ciphers over any finite field.*

We generalize the Advanced Encryption Standard (AES), which operates on the finite field $\text{GF}(2^8)^{4 \times 4}$, to a class of AES-like ciphers which operate on any finite field $\text{GF}(p^r)^{mn}$. Sparr and Wernsdorf have explored such ciphers for $p = 2$. We determine the parity of each of the four component functions of these ciphers. We then provide conditions under which the rounds of these ciphers generate the alternating or symmetric group on the state space. Our work suggests when multiple encryption might effectively increase the security of such ciphers. (Received January 19, 2013)

1088-20-47 **Carrie A. Whittle*** (cawhittl@uark.edu). *The word problem in the automorphism groups of right-angled Artin groups is in P.* Preliminary report.

We construct a polynomial-time algorithm for the word problem in the automorphism groups of right-angled Artin groups. Our techniques generalize those of Schleimer where he finds a polynomial-time solution to the word problem for automorphism groups of free groups. (Received January 28, 2013)

1088-20-65 **Nham Vo Ngo*** (ngon@uwstout.edu), MSCS Department, University of Wisconsin-Stout, MENOMONIE, WI 54751. *Nilpotent commuting varieties.*

We present in this talk our results on the variety of commuting tuples of nilpotent matrices and some other related varieties. In particular, we discuss about the irreducibility, normality, and Cohen-Macaulayness of these varieties. Moreover, we show their applications to the cohomology of Frobenius kernels for algebraic groups. (Received February 02, 2013)

1088-20-71 **Mark Sapir*** (m.sapir@vanderbilt.edu), SC 1326, Department of Mathematics, Vanderbilt University, BNA, TN 37221. *Complicated residually finite groups.*

I will show how to construct finitely presented residually finite groups with prescribed (recursive) Dehn function, prescribed complexity class of the word problem and prescribed (recursive) depth function. This is a joint work with A. Myasnikov and Olga Kharlampovich. (Received February 02, 2013)

1088-20-167 **Benjamin Fine*** (fine@fairfield.edu), **Martin Kreuzer** (martin.kreuzer@uni-passau.de) and **Gerhard Rosenberger** (gerhard.rosenberger@math.uni-hamburg.de). *CONSTRUCTIVE FAITHFUL REPRESENTATIONS INTO $PSL(2, \mathbb{C})$ AND $PSL(2, R)$.*

Abstract: Constructive linear representations can play a large role in the algorithmic theory of infinite groups. The groups $PSL(2, \mathbb{C})$ and $PSL(2, R)$ are especially important in this regard. The vast majority of the theory of discrete groups can be placed within these two groups. Fine and Rosenberger showed that any finitely generated fully residually free group has a faithful representation into $PSL(2, \mathbb{C})$ and further if the group is hyperbolic this representation can be effectively constructed from the JSJ decomposition of the group. Recall that a cyclically pinched one-relator groups is a free product with amalgamation of 2 free groups with infinite cyclic amalgamated subgroup given by $U = V$ where U and V are words in the free group factors. Here we show that if U and V

are nonprimitive and not proper powers then the resulting cyclically pinched one-relator group has a faithful two-dimensional real representation, that is a faithful representation into $PSL(2, \mathbb{R})$. The same result extends to groups of F-type which are a natural generalization of Fuchsian groups.

These results are tied to older problems related to representations of surface groups and more generally Fuchsian groups into Lie Groups. (Received February 09, 2013)

1088-20-178 **Ashley Johnson*** (203 Avery Hall, Lincoln, NE 68588-0130). *An Algorithmic and Geometric Property of Cayley Graphs.*

Autostackability is an algorithmic and geometric property of a Cayley graph of a group, which arose as a way to gain tractability on algorithmic problems in the class of 3-manifold groups. Autostackability generalizes the algorithmic structure of both almost convex groups and groups with rewriting systems, and includes all shortlex automatic groups. This talk will present an overview of autostackable groups, as well as show closure properties for this class of groups and show that not all such groups are of type FP_∞ . (Received February 09, 2013)

1088-20-192 **Svetla Vassileva*** (svassileva@math.mcgill.ca). *The conjugacy problem in wreath products is decidable in log-space.*

We show that the conjugacy problem in the restricted wreath product $A \wr B$ is decidable in log-space provided the conjugacy problems in A and B and the power problem in B are decidable in log-space. We conclude that the conjugacy problem in the wreath product of two abelian groups is decidable in log-space. (Received February 10, 2013)

1088-20-198 **Maggie E Habeeb*** (habeeb@calu.edu), 250 University Ave, Mathematics, Computer Science, and Information Systems, California, PA 15419, and **Delaram Kahrobaei** (dkahrobaei@gc.cuny.edu), 365 Fifth Avenue, New York, NY 10016. *Dimension of Matrix Representations of Finitely Generated Torsion Free Nilpotent Groups.*

It is well known that any polycyclic group, and hence any finitely generated nilpotent group, can be embedded in $GL_n(\mathbb{Z})$ for some $n \in \mathbb{N}$; that is, each element in the group has a unique matrix representation. In this talk, we will describe an algorithm (due to W. Nickel) that determines this embedding. We determine the complexity of the crux of the algorithm and the dimension of the matrices produced. (Received February 10, 2013)

1088-20-213 **Peter A Brooksbank*** (pbrooks@bucknell.edu). *Simple groups acting on polytopes.*

Much effort has been devoted recently to the problem of classifying members of various infinite families of finite simple groups that arise as the group of automorphisms of an abstract regular polytope. The situation is well understood for simple classical groups whose underlying projective space is a line or a plane. This talk considers simple linear groups of higher dimension. (Received February 11, 2013)

1088-20-217 **Sang-hyun Kim** and **Thomas Koberda*** (thomas.koberda@gmail.com). *Curve complexes for right-angled Artin groups.*

I will discuss an analogue of the curve complex for right-angled Artin groups and describe some of its properties. I will then show how it guides parallel results between the theory of mapping class groups and the theory of right-angled Artin groups. (Received February 11, 2013)

1088-20-234 **Simon M Smith*** (sismith@citytech.cuny.edu), Department of Mathematics, City Tech, City University of New York, 300 Jay Street, Brooklyn, NY 11201. *Computationally interesting properties of infinite permutation groups with finite stabilizers.*

My recent research involves investigating the structure of infinite permutation groups with finite stabilizers. Like finitely generated abstract groups, these groups have many properties that are computationally difficult to determine, but unlike finitely generated groups little has been written about computing these properties.

This talk will be an introduction to the structure theory of infinite permutation groups with finite stabilizers, and I will try to highlight properties of these groups that might be computationally interesting. (Received February 11, 2013)

1088-20-247 **Alexei Miasnikov** (amiasnikov@gmail.com), Department of Mathematical Sciences, Schaefer School of Engineering & Science, Stevens Institute of Technology, Hoboken, NJ 07030, and **Dmytro Savchuk*** (savchuk@usf.edu), Department of Mathematics and Statistics, University of South Florida, Tampa, FL 33620. *An Example of an Automatic Graph of Intermediate Growth.* Preliminary report.

We give the first example of a 4-regular infinite automatic graph of intermediate growth. It is constructed as a Schreier graph of a 2-generated self-similar group. (Received February 11, 2013)

1088-20-253 **Olga Kharlampovich*** (okharlampovich@gmail.com). *Using automata to solve algorithmic problems in relatively hyperbolic groups.*

One can associate to any subgroup of a free group a so-called Stallings automaton, i.e. a finite oriented labeled graph, that accepts only elements of H . Given generators of a finitely generated subgroup H of a free group F we can compute its basis and solve the membership problem using Stallings automaton. There is an algorithm to find the intersection of conjugates of two finitely generated subgroups of F using the product of their automata.

We will describe how to construct similar automata for finitely generated relatively quasi-convex subgroups of relatively hyperbolic groups and how to solve different algorithmic problems for them. These are joint results with A. Myasnikov. (Received February 11, 2013)

1088-20-255 **James M Belk*** (belk@bard.edu) and **Bradley T Forrest** (bradley.forrest@stockton.edu). *A Thompson Group for the Basilica.*

In the 1960's, Richard J. Thompson described three groups F , T , and V , which act by homeomorphisms on the interval, the circle, and the Cantor set, respectively. In this talk, I will describe an analogous group that acts by homeomorphisms on the Basilica Julia set. This group can also be described as a group of piecewise-linear homeomorphisms of the unit circle that preserves the invariant lamination determined by the Basilica. (Received February 12, 2013)

1088-20-275 **Shafi Goldwasser*** (shafi@theory.csail.mit.edu), 32 Vassar St. G-682, Cambridge, MA 02139. *Current Challenges in Information Security.*

We will describe some of the modern security challenges raised by cloud computing, such computing on encrypted data and delegating memory and computation to untrusted servers. There have been some exciting developments in this field in the last few years, including the development of fully homomorphic encryption, functional encryption, and delegation of garbled computation which we will describe. (Received February 12, 2013)

22 ► *Topological groups, Lie groups*

1088-22-49 **Alfred Gerard Noel*** (alfred.noel@umb.edu), 100 Morrissey Boulevard, Boston, MA 02125. *Some Combinatorics of Dynkin-Kostant Diagrams.*

This will be an expository talk on some combinatorial aspects of Vinberg's classification of nilpotent orbits in graded Lie algebras. (Received January 29, 2013)

1088-22-195 **Birgit Speh*** (speh@math.cornell.edu) and **Mahdi Asgari** (asgari@math.cornell.edu). *Arthur packet of small symplectic groups.* Preliminary report.

We study non-tempered Arthur packets of representations in the discrete spectrum of some small rank symplectic groups and determine which ones are residual, CAP, etc. We also point out those with nontrivial cohomology. (Received February 10, 2013)

1088-22-245 **Nimish A Shah*** (shah@math.ohio-state.edu), The Ohio State University, 100 Math Tower, 231 W 18th Ave, Columbus, OH 43210-1174, and **Manfred Einsiedler, Shahar Mozes** and **Uri Schapira**. *Equidistribution of primitive rational points on expanding horosphere.* Preliminary report.

We prove a result on equidistribution of certain sparse collections of points of arithmetic nature on expanding horospheres. This collections are obtained by intersecting the expanded horospheres with a certain stable manifold of complementary dimension. Using this result one can obtain analogue of a result of W. Schmidt regarding the distribution of shapes of lattices orthogonal to integer vectors. (Received February 11, 2013)

32 ► *Several complex variables and analytic spaces*

1088-32-129 **Duong H Phong*** (phong@math.columbia.edu), Department of Mathematics, Columbia University, New York, NY 10027. *On the singularities of the pluricomplex Green's function.*

In several complex variables, the classical Green's function becomes the solution of a complex Monge-Ampère equation with a Dirac measure on the right hand side. We discuss the construction of such Green's functions by methods combining geometric blow-ups with new a priori estimates for the complex Monge-Ampère equation. (Received February 06, 2013)

34 ► Ordinary differential equations

1088-34-97 **Sarah Jean Bober*** (sjbober@wpi.edu), 310 Bungay Hill Road, Woodstock, CT 06281.
Modelling Cancer Stem Cell and Non-Stem Cancer Cell Population Growth.

The Cancer Stem Cell Hypothesis states that there are two types of cancer cells: cancer stem cells and non-stem cancer cells. Stem cells have unlimited proliferation capacity and can initiate and drive tumor growth. These cells can give rise to mortal non-stem cancer cells with unknown but limited proliferation potential, m . In this project, we developed several new models in order to conduct mathematical and numerical investigations of the dynamics of the interactions between these two populations. First, we built linear multi-compartment ODE models and found their analytic and steady-state solutions and performed sensitivity analyses. The sizes of the stem and non-stem populations were compared to see the effect of accounting for generational age. We also built a 2-compartment model capturing the multi-component results. Next, we developed a nonlinear model that takes into account competition for resources by using proliferation rates that decline as the cell population rises. Lastly, we developed a system of 1D PDEs for the non-stem generations where they diffuse and experience population pressure; stem cells act as point sources. We wrote a finite volume method to numerically solve the PDE. (Received February 04, 2013)

1088-34-120 **Nadia Marie Ott*** (nadiaott@yahoo.com), 5787 College Ave. Apt 46, San Diego, CA 92120, and **Timothy Mark Dunster**. *Reduction of Order for Higher Order Linear Ordinary Differential Equations.* Preliminary report.

Reduction of order is a technique in mathematics used to solve ordinary differential equations. While its usefulness to higher order equations is often disregarded it is, in theory, applicable to n th-order equations. In practice, reduction of order is rarely constructive for equations of higher than second order due to severe practical difficulties. However, the powerful method of variation of parameters is primarily a clever modification of reduction of order. Recognizing this important relationship provides incentive to further explore the applicability of reduction of order to higher order differential equation. An innovative approach using reduction of order to solve higher order differential equations using Abel's differential equation identity and the definition of the Wronskian is demonstrated by this research. Exploring the applicability of the method of reduction of order to higher order differential equations is an essential step in fully utilizing the method throughout the field of differential equations. Given the many applications of variation of parameters in the field of partial differential equations (e.g., as a method to solve the heat and wave equations) it follows that reduction of order could be useful in such a context. (Received February 06, 2013)

35 ► Partial differential equations

1088-35-18 **Maxim Olshanii*** (maxim.olchanyi@umb.edu), University of Massachusetts Boston, 100 Morrissey Blvd., Boston, MA 02125, **Zaijong Hwang** (zaijong.hwang001@umb.edu), University of Massachusetts Boston, 100 Morrissey Blvd., Boston, MA 02125, and **Andrew Koller** (andrewpkoller@gmail.com), JILA University of Colorado 440 UCB, Boulder, CO 80309. *On a relationship between reflectionless potentials, Lax operators, Bogoliubov-de Gennes Liouvilleans of integrable PDEs, and supersymmetric chains.* Preliminary report.

We look at several instances of reflectionless scattering, the evolution of a two-level atom under a $\text{sech}(t)$ laser pulse in particular. For each of them, we analyse its connection to three other objects: an integrable PDE for whom a given reflectionless scatterer serves as a Lax operator, another integrable PDE whose linear stability analysis equation (LSA) is represented by the above scatterer, and a trivial linear equation with constant coefficients to which the scatterer is linked via a so-called *intertwiner* or via a supersymmetric (SUSY) chain.

In particular, the $\text{sech}(t)$ problem mentioned above shows a rich SUSY structure [Koller & Olshanii, Physical Review E 84, 066601 (2011)]; at the same time it serves as a Lax operator for a class of n -soliton solutions of both Nonlinear Schrödinger (NLS) and sine-Gordon (sG) equations. LSA around single soliton solutions of the sG, NLS and Korteweg-de Vries (KdV) equations exhibit reflectionless scattering; furthermore, they can be shown to have an intertwining property, extendable to SUSY in the sG case. Finally, there is an intriguing possibility that known cases of reflectionless scattering, when regarded as LSA, can be used to discover previously unknown integrable PDEs. (Received December 14, 2012)

1088-35-24 **Wen-Xiu Ma*** (mawx@cas.usf.edu), Department of Mathematics and Statistics, University of South Florida, 4202 E Fowler Avenue, Tampa, FL 33620-5700. *Wronskian Formulations of the Boussinesq Equations.*

Wronskian and Casoratian determinants are used to solve soliton equations analytically. We will talk about the Wronskian formulations for the Boussinesq equations. Various solutions including rational solutions, solitons, positons and complexitons are generated from their corresponding Hirota bilinear equations. (Received December 18, 2012)

1088-35-27 **Steve Zelditch*** (zelditch@math.northwestern.edu). *Weyl laws, Grauert tubes and Laplace eigenfunctions.*

Let (M, g) be a real analytic Riemannian manifold. The pointwise Weyl laws give asymptotics and remainder estimates for sums over eigenvalues of squares $\phi_j(x)^2$ of Laplace eigenfunctions. The remainder can be expressed in terms of geodesics loops at x . Together with Sogge (2003) and Sogge-Toth (2011), we related maximal growth of L_p norms to measures of geodesic loops at x . In this talk, I consider analytic continuations of eigenfunctions to a Grauert tube of M and give pointwise Weyl laws in the complex domain. They are phase space local Weyl laws. The remainders turn out to depend only on whether the phase space point is a periodic point for the geodesic flow. I.e. the remainder is in terms of smoothly closed geodesics and not all loops. Inverting the Poisson (FBI) transform gives results on eigenfunction growth in the real domain. (Received January 13, 2013)

1088-35-36 **Joseph L Shomberg*** (jshomber@providence.edu), Providence College, Department of Mathematics and Computer Scienc, 212 Howley Hall, Providence, RI 02918, and **Ciprian G Gal**. *Global Attractors of the Hyperbolic Relaxation of Reaction-Diffusion Equations with Dynamic Boundary Conditions.*

Under consideration is the hyperbolic relaxation of the semilinear reaction-diffusion equation,

$$\varepsilon u_{tt} + u_t - \Delta u + f(u) = 0,$$

$\varepsilon \in [0, 1]$, with the prescribed dynamic boundary condition,

$$\partial_n u + u + u_t = 0.$$

For all singular and nonsingular values of the perturbation parameter, we obtain global attractors with optimal regularity. After fitting both problems into a common framework, a proof of the upper-semicontinuity of the family of global attractors is given. The result is motivated by the seminal work of J. Hale and G. Raugel in *Upper semicontinuity of the attractor for a singularly perturbed hyperbolic equation*, J. Differential Equations 73 (1988). (Received January 21, 2013)

1088-35-58 **Frederic Rochon*** (rochon.frederic@uqam.ca), Departement de Mathematiques, Universite du Quebec a Montreal, C.P. 8888, Succ. Centre-Ville, Montreal, QC H3C3P8, Canada. *Polyhomogeneity for asymptotically complex hyperbolic Kähler metrics under the Ricci flow.*

We will show that the polyhomogeneous behavior at infinity of an asymptotically complex hyperbolic Kähler metric is preserved when such a metric is evolved according to the Ricci flow. (Received January 30, 2013)

1088-35-85 **Camelia A. Pop*** (cpop@math.upenn.edu) and **Paul M. N. Feehan** (feehan@rci.rutgers.edu). *Degenerate elliptic operators in mathematical finance and Hölder continuity for solutions to variational equations and inequalities.*

The Heston stochastic volatility process, which is widely used as an asset price model in mathematical finance, is a paradigm for a degenerate diffusion process where the degeneracy in the diffusion coefficient is proportional to the square root of the distance to the boundary of the half-plane. The generator of this process with killing, called the elliptic Heston operator, is a second-order, degenerate-elliptic partial differential operator whose coefficients have linear growth in the spatial variables and where the degeneracy in the operator symbol is proportional to the distance to the boundary of the half-plane. With the aid of weighted Sobolev spaces, we prove supremum bounds, a Harnack inequality, and Hölder continuity near the boundary for solutions to variational equations defined by the elliptic Heston operator, as well as Hölder continuity up to the boundary for solutions to variational inequalities defined by the elliptic Heston operator. In mathematical finance, solutions to obstacle problems for the elliptic Heston operator correspond to value functions for perpetual American-style options on the underlying asset. (Received February 04, 2013)

1088-35-87 **Xiaojing Wang*** (cathw@wpi.edu), 100 Institute Road #3706, Worcester, MA 01609. *A Nonlinear Reaction-Diffusion-Conduction Problem for Solid Oxide Fuel Cells (SOFCs).*

This talk considers a nonlinear steady-state reaction-diffusion-conduction problem for solid oxide fuel cells (SOFCs). The existence of a solution to this problem is proven by showing the existence of a minimum of

an appropriate energy functional, then the Dirichlet principle is used to show that the minimum is a solution to the original problem. The uniqueness of the solution can be proven by application of Green's first identity. Numerical computations of the solution for certain parameter values are presented. (Received February 04, 2013)

1088-35-100 **Chuqiao Yang*** (chuqiao@wpi.edu), 100 Institute Road, Worcester, MA 01609, and **Vadim Yakovlev**. *A Simple Heat Transfer Model for Reactors in Microwave-Assisted Chemistry.*

This study is concerned with a heat transfer problem in a three-medium cylindrical domain that represents a core element of a typical reactor employed in microwave-assisted chemistry. Microwave heating has such benefits as accelerated reaction rate, higher chemical yield, and lower energy use compared to conventional heating methods. However, new controllable and reproducible reaction routes can be developed only when keeping temperature evolution in the reactant under control.

In this work, we propose a simple, computationally inexpensive mathematical model that predicts temperature growth in the reactor in response to the absorbed microwave power. The heat transfer problem is solved for a 3-medium cylindrical domain, with an adiabatic boundary condition applied at the outer boundary of this structure. The model assumes that temperature of the reactant remains uniform, as this is normally the case due to convection flows or mechanical stirring. A system of heat equations for different media is reduced to a linear system of differential equations whose solution determines temperature throughout the domain. The model is validated by experimental results obtained with MiniFlow 200SS reactor by SAIREM SAS. (Received February 04, 2013)

1088-35-106 **Jesse David Gell-Redman*** (jgell@math.toronto.edu), Room 6290, 40 St. George Street, Toronto, ON M5S 2E4, Canada. *The heat kernel of the Weil-Petersson Laplacian on Riemann moduli space.*

Inspired by recent work of Ji, Mazzeo, Müller, and Vasy on the Laplacian of the Weil-Petersson metric on the Riemann moduli space, we construct the integral kernel of the fundamental solution to the heat equation for the same metric. The Weil-Petersson metric is an incomplete metric on a smooth manifold, singular on a finite family of immersed divisors which cross normally. Following work of Melrose and many others, the behavior of the heat kernel is described by its asymptotic behavior in various regimes, i.e. as the time t goes to zero and the ratios of t and certain powers the distance functions from the divisors stay bounded. The most useful way of approaching the latter process is to construct a space via radial blowup on which the heat kernel pulls back to have asymptotic expansions at the boundary faces; in particular from this we can deduce the asymptotics of the trace of the heat kernel directly using more work of Melrose. (Received February 05, 2013)

1088-35-140 **Xiao Shen*** (xshen@wpi.edu), 11 Cedar Square, Millis, MA 02054. *Extreme Cases of the p -Laplace Operator.*

Abstract:

In the classic theory, p -Laplace operator ($1 < p < +\infty$) joined several main parts of the mathematics in a fruitful way, and one important principle of mathematics is that extreme cases reveal interesting structure. Looking at p -Laplace operator as subgradients of a sequence of convex functionals $\{Ep\}$, as p goes to 1 and to infinity, we present the connection of the "dual problem" between 1-Laplace operator and infinity-Laplace operator using tools from convex analysis and the notion of Mosco convergence. (Received February 07, 2013)

1088-35-161 **Zuoqin Wang*** (wangzuoq@umich.edu), 530 Church Street, Ann Arbor, MI 48109. *Semiclassical spectral invariants for perturbed harmonic oscillators.*

In this talk we will introduce some semiclassical spectral invariants for perturbed harmonic oscillators, and use these invariants to study some inverse spectral problems. This is a joint work with V. Guillemin and A. Uribe. (Received February 08, 2013)

1088-35-187 **Justin Holmer*** (holmer@math.brown.edu) and **Donlapark Pornnopparith**. *Near amplitude crossing of mKdV double solitons.*

The mKdV equation $\partial_t u = \partial_x(-u_{xx} - 2u^3)$ admits double-soliton solutions, obtained via inverse scattering theory, with parameters of position and amplitude. We prove a new asymptotic decomposition formula for the double-soliton profile into the sum of two single-solitons that remains valid as the amplitude parameters coincide. Using this formula, we give an explanation of the avoided-crossing phenomena discussed in Holmer, Perelman, & Zworski (2011), that emerges when one considers the dynamics of a double-soliton under the influence of a slowly-varying potential, i.e. as an approximate solution to $\partial_t u = \partial_x(-u_{xx} + bu - 2u^3)$, for $b(x, t) = b_0(hx, ht)$ and $0 < h \ll 1$. The avoided-crossing is a dynamical scenario in which the scales of the two solitons become

exponentially close inducing an abrupt switch in position of the two solitons. The results are supported by numerical computations. (Received February 10, 2013)

1088-35-259 **Hamid Hezari***, 510J Rowland Hall, UC Irvine, Irvine, CA 92697. *The Calderon problem with partial data*. Preliminary report.

In this talk we give a simple proof for a theorem of Imanuvilov, Uhlmann and Yamamoto. Their result shows that for a two dimensional bounded domain the Cauchy data for the Schrödinger equation measured on an arbitrary open subset of the boundary determines uniquely the potential. For the conductivity equation, this shows that current measurements at the boundary on an arbitrary open subset of the boundary produced by voltage potentials supported in the same subset, determines uniquely the conductivity. In our proof we will not use Carleman estimates with degenerate weight functions. Surprisingly we only use linear phase functions. (Received February 12, 2013)

1088-35-271 **Shabnam Beheshti*** (beheshti@math.rutgers.edu), Department of Mathematics, Hill Center, 110 Frelinghuysen Road, Piscataway, NJ 08854. *An Integrability Toolkit for Combinatorialists*.

We introduce the notion of integrable partial differential equations and provide a survey of the literature connecting integrability and combinatorics. Using several classical examples from shallow-water wave theory, we discuss classical integrability techniques (Lax systems, Backlund transforms, Hirota form, Wronskian solutions) in this modern context. The talk will be at an introductory level, with the aim of motivating further exploration and collaboration between researchers in both fields. (Received February 12, 2013)

37 ► *Dynamical systems and ergodic theory*

1088-37-59 **Amir Mohammadi*** (amir@math.utexas.edu). *Unipotent flows and infinite measures*.

Unipotent flows on homogeneous spaces obtained as a quotient of a Lie group by a lattice have been an important subject of study in the past four decades or so. Recently some developments have been made towards the study of unipotent flows on homogeneous spaces preserving a geometric but infinite measure; in this talk we will highlight the similarities and main differences between these two settings. This talk is based on a joint work with H. Oh. (Received January 31, 2013)

1088-37-74 **Han Li*** (li.han@yale.edu), 10 Hillhouse Ave., New Haven, CT 06520. *Effective Equidistributions of Farey Sequence and Limit Distributions of Frobenius Numbers*.

Jens Marklof proved in 2011 a limit distribution of the Frobenius numbers, based on an effective equidistribution result of the Farey sequence on expanding horospheres. In this talk we will discuss how to get an effective version of the corresponding results. (Received February 03, 2013)

1088-37-134 **Ilya Vinogradov*** (ilya.vinogradov@bristol.ac.uk), School of Mathematics, University of Bristol, Bristol, BS8 1TW, United Kingdom. *Equidistribution of generalized Farey points and applications to counting*.

Given a finite dimensional representation $\pi: G = \mathrm{SL}(d, \mathbb{R}) \rightarrow \mathrm{GL}(V)$ we define generalized Farey sets of a lattice Γ in G and prove that each Farey set equidistributes on a submanifold in $\Gamma' \backslash G$ depending on commensurability of Γ and Γ' . The case $V = \mathbb{R}^d$, π the usual representation, and $\Gamma = \Gamma' = \mathrm{SL}(d, \mathbb{Z})$ corresponds to the standard Farey points in \mathbb{Q}^{d-1} . We apply the equidistribution result to refine the theorem of Schmidt on counting the number of equivalence classes of lattices of \mathbb{Z}^d . Joint work with Jens Marklof. (Received February 07, 2013)

1088-37-143 **Dmitry Kleinbock** (kleinboc@brandeis.edu), 415 South Street, Goldsmith MS 050, Waltham, MA 02453, and **Keith Merrill***, 415 South Street, Goldsmith 050, Waltham, MA 02453. *Rational Approximation on Spheres*.

We quantify the density of rational points in the unit sphere S^n , proving analogues of the classical theorems on the embedding of \mathbb{Q}^n into \mathbb{R}^n . Specifically, we prove a Dirichlet theorem stating that every point $\alpha \in S^n$ is sufficiently approximable, the optimality of this approximation via the existence of badly approximable points, and a Khintchine theorem showing that the Lebesgue measure of approximable points is either zero or full depending on the convergence or divergence of a certain integral. These results complement and improve on previous results, particularly recent theorems of Ghosh, Gorodnik and Nevo.

Time permitting, we will discuss the analogous situation for levels sets of general quadratic forms. (Received February 07, 2013)

- 1088-37-185 **Anupam Bhatnagar*** (abhatnagar@bmcc.cuny.edu) and **Alon Levy** (levy@math.ubc.ca). *Isotriviality of Algebraic Dynamical Systems over Function Fields.*
Let C be a smooth projective curve defined over a field k and let K denote the function field of C . Let (X, ϕ) be an algebraic dynamical system, where X is a projective K -variety and $\phi : X \rightarrow X$ a K -morphism. In this talk we shall discuss criteria for isotriviality of X and ϕ . (Received February 10, 2013)
- 1088-37-186 **Zhiren Wang*** (zhiren.wang@yale.edu), Yale Univ., Dept. of Mathematics, PO Box 208283, New Haven, CT 06520. *Rigidity of Actions by Commuting Nilmanifold Automorphisms.*
Consider a faithful \mathbb{Z}^r -action on a nilmanifold N by automorphisms. Theorems of Berend, Katok-Spatzier and Einsiedler-Lindenstrauss assert that when N is a torus, if the action is hyperbolic, strongly irreducible and of rank $r \geq 2$, then invariant closed subsets and measures are very scarce. In this talk, we will explain how such rigidity properties pass from the base torus of a nilmanifold to the nilmanifold itself. (Received February 10, 2013)
- 1088-37-287 **Wesley Pegden*** (pegden@math.nyu.edu), **Charles K Smart** (smart@math.mit.edu) and **Lionel Levine** (levine@math.cornell.edu). *Apollonian structure in the Abelian sandpile.*
The Abelian sandpile is a chip-firing game on the lattice which can be viewed as a simple deterministic analog to stochastic diffusion processes based on random walks. In contrast to its stochastic counterparts, the sandpile produces striking fractal scaling limits which have long resisted explanation, or even precise description. In this talk, we will survey a new approach to understanding the fractal behavior of the sandpile, which begins by identifying sandpile limits as solutions of a certain PDE. The heart of our results is a surprising connection between the integer superharmonic functions on the lattice which govern this PDE and Apollonian circle packings of the plane, which allows a characterization of certain fractal solutions produced by the sandpile. (Received February 13, 2013)

39 ► *Difference and functional equations*

- 1088-39-60 **Mustafa R.S. Kulenovic***, mkulenovic@mail.uri.edu, Kingston, RI, and **Midhat Mehuljic**, University of Sarajevo, Sarajevo. *Global Behavior of Some Rational Second Order Difference Equations.*
We investigate the global behavior of five special cases of the difference equation of the form
$$x_{n+1} = \frac{\alpha + \beta x_n x_{n-1} + \gamma x_{n-1}}{A + B x_n x_{n-1} + C x_{n-1}}, \quad n = 0, 1, \dots$$
with non-negative parameters and initial conditions such that $A + B + C > 0$ and with several equilibrium points. We will prove that for four of these five equations the unique equilibrium is globally asymptotically stable and for the fifth equation that the unique equilibrium is stable but not asymptotically stable. We will extend some of the obtained results to difference equations of any order. (Received January 31, 2013)
- 1088-39-68 **A. Brett*** (ann.brett@jwu.edu) and **M. Kulenovic** (kulenm@math.uri.edu). *Attractivity and Global Stability for Linear Fractional Difference Equation.*
Consider the difference equation
$$x_{n+1} = \frac{\alpha + \sum_{i=0}^k a_i x_{n-i}}{A + \sum_{i=0}^k b_i x_{n-i}}, \quad n = 0, 1, \dots$$
where all parameters $\alpha, A, a_i, b_i, i = 0, 1, \dots, k$ and the initial conditions $x_i, i \in \{-k, \dots, 0\}$ are nonnegative. We investigate the asymptotic behavior of the solutions of the considered equation. We give easy-to-check conditions for global attractivity of zero or positive equilibrium of this equation. (Received February 02, 2013)
- 1088-39-95 **Evelina G Lapierre*** (elapierre@jwu.edu), **Dan Hadley**, **Edward Grove** and **Sam Schultz**. *An application of the Kulenovic-Ladas-Sizer Theorem on a system of rational difference equations.*
We investigate the system of rational difference equations: $x_{n+1} = \frac{\alpha_1}{x_n + y_n}$ and $y_{n+1} = \frac{\alpha_2 + \beta_2 x_n + y_n}{y_n}$ where the parameters and the initial conditions are positive real numbers. We show that the system is permanent and has a unique positive equilibrium which is locally asymptotically stable. We also find sufficient conditions to insure that the unique positive equilibrium is globally asymptotically stable. (Received February 04, 2013)

1088-39-122 **M.R.S. Kulenovic** and **M. DiPippo*** (mdipippo@ric.edu). *Global Dynamics of Some Anti-competitive Systems of Difference Equations in the Plane.*

We investigate the global dynamics of several anti-competitive systems of rational difference equations which are special cases of general linear fractional system of the form

$$x_{n+1} = \frac{\alpha_1 + \beta_1 x_n + \gamma_1 y_n}{A_1 + B_1 x_n + C_1 y_n}, \quad y_{n+1} = \frac{\alpha_2 + \beta_2 x_n + \gamma_2 y_n}{A_2 + B_2 x_n + C_2 y_n}, \quad n = 0, 1, \dots,$$

where all parameters and the initial conditions x_0, y_0 are arbitrary nonnegative numbers such that both denominators are positive. We find the basins of attraction of all attractors of this system.

(Received February 06, 2013)

1088-39-123 **William T Jamieson*** (bill@math.uri.edu), 5 Lippitt Road, Department of Mathematics, Kingston, RI 02881, and **Orlando Merino** (merino@math.uri.edu), 5 Lippitt Road, Department of Mathematics, Kingston, RI 02881. *On the Asymptotic Behavior of Convergent Solutions to Difference Equations of the Type $x_{n+1} = Jx_n + f_n(x_n)$.*

The asymptotic behavior of convergent solutions to difference equations of the type

$$x_{n+1} = Jx_n + f_n(x_n)$$

for $n \geq 0$, where $J \in \mathbb{C}^{m \times m}$ and $f_n(x) : \mathbb{C}^m \rightarrow \mathbb{C}^m$ is continuous for each n is considered.

C. V. Coffman showed under suitable hypotheses that if \bar{x} denotes the limit of a convergent solution $\{x_n\}$, then there exist $y \in \mathbb{C}^m$ and a positive number ρ such that ρ is equal to the modulus of one the characteristic roots of J , that $\|x_n\|^{1/n} = \rho + o(\rho^n)$, and $x_n = \bar{x} + J^n y + E_n$, where $E_n = o(n^k \rho^n)$. Our results give a precise formulation of the asymptotic error E_n . (Received February 07, 2013)

1088-39-128 **Chris D Lynd*** (chris@math.uri.edu). *Anti-Competitive Systems of Rational Difference Equations.* Preliminary report.

If F is an anti-competitive map, then the map F^2 , the second iterate of F , is a competitive map. We will discuss the global behavior of the solutions of several systems of rational difference equations whose corresponding map is anti-competitive. We will demonstrate several general properties of these systems. (Received February 06, 2013)

1088-39-151 **Frank J Palladino*** (frank@math.uri.edu). *Toward a Classification of Periodic Trichotomies.* Preliminary report.

We discuss periodic bifurcations for linear fractional rational difference equations with nonnegative parameters and nonnegative initial conditions. We unify all known periodic trichotomy results into three general families of periodic trichotomies. (Received February 08, 2013)

1088-39-241 **Emmanouil Drymonis*** (mdrymonis@math.uri.edu), Department of Mathematics, University of Rhode Island, Kingston, RI 02881. *Patterns of Boundedness of Rational Systems in the Plane.*

We present the patterns of boundedness of some rational systems in the plane. We establish easily verifiable necessary and sufficient conditions, explicitly stated in terms of the parameters of the systems, which determine the boundedness character of all special cases of the systems. Some global stability results are also presented. (Received February 11, 2013)

1088-39-266 **Daniel M Hadley*** (dhadley@mail.uri.edu), Department of Mathematics, University of Rhode Island, Kingston, RI. *Global dynamics of some second order quadratic fractional difference equation.* Preliminary report.

We consider the following quadratic fractional difference equation

$$x_{n+1} = \frac{Ax_n^2 + Cx_{n-1}^2 + Ex_{n-1}}{ax_n^2 + cx_{n-1}^2 + ex_{n-1}}, \quad n = 0, 1, \dots$$

with all coefficients and initial conditions non-negative. Such equation can have at most two positive equilibrium solutions and several periodic solutions. We investigate local stability of the equilibrium solutions and of periodic solutions. We find the basins of attraction of both of these solutions and give a global dynamics of the considered equation in several regions of parameters. (Received February 12, 2013)

47 ► Operator theory

1088-47-290 **Driss Drissi*** (drissi99@yahoo.com). *Hyperinvariance for a class of operators*. Preliminary report.

In this work, we associate to each normal operator N the resolvent algebra of operators in $L(X)$. Frequently this algebra contains the commuting of the associated operator. For a subclass of normal operators we prove that the algebra has a nontrivial invariant subspaces and present some properties of this algebra. (Received February 14, 2013)

49 ► Calculus of variations and optimal control; optimization

1088-49-20 **Baiba Zvirgzdina*** (baiba.zvirgzdina@inbox.lv). *Simulation-based Metaheuristic Optimization of Logistics Systems*. Preliminary report.

Simulation models are important for planing, implementing and operating logistics systems since they can depict their dynamic system behavior. In the field of logistics, discrete-event models are widely used. Their creation and computation is often very time and labor consuming. For this reason, the paper reviews optimization methods for simulation models to quickly and effectively execute analysis and planning tasks related to production and logistics systems. The paper reviews literature that describes the latest research in optimization methods for simulation models that are widely used. Most of those methods discussed in this paper are metaheuristics. Metaheuristics have a good trade-off between solution quality and computing time, especially for complex problems or large problem instances. (Received December 16, 2012)

51 ► Geometry

1088-51-42 **Leah Wrenn Berman, Mark Mixer and Barry Monson***, Dept. of Math. and Stats., UNB, Fredericton, NB E3B 5A3, Canada, and **Deborah Oliveros and Gordon Williams**. *The Extreme Pyramids*.

The monodromy group $M(\mathcal{P})$ for a polyhedron \mathcal{P} (or indeed for any convex, even abstract, d -polytope \mathcal{P}) is a combinatorial invariant of \mathcal{P} . This group somehow encodes the essential structural features of the polytope. Recently we have completely described $M(\mathcal{P})$ when \mathcal{P} is an ordinary pyramid, whose base is an n -gon. Though \mathcal{P} itself is very familiar, $M(\mathcal{P})$ has some lovely features.

Here we discuss the extreme cases $n = 2$ and ∞ . In the first instance, when \mathcal{P} is the rather modest pyramid over the digon, $M(\mathcal{P})$ is, surprisingly, isomorphic to the symmetry group of a 4-cube. And, at the other extreme, when $n = \infty$, $M(\mathcal{P})$ acts, in a natural way, as a crystallographic group in real 4-space. (Received January 23, 2013)

1088-51-127 **Brigitte Servatius*** (bservat@wpi.edu), Mathematical Sciences, WPI, Worcester, MA 01609, and **Herman Servatius**. *On auto-polarity*. Preliminary report.

A self-duality of rank two is called polarity. It is known that the smallest incidence structure that is self-dual but not self-polar is of order 6. For self-polar point-line or point-face incidence structures we ask if the polarity can be realized as a polarity with respect to the unit circle or sphere. If a polarity takes the object into itself, we call it auto-polar. We give examples of self-polar polyhedra that are not auto-polar. (Received February 06, 2013)

1088-51-181 **Jonah Gaster*** (jbgaster@gmail.com), Chicago, IL. *A family of non-injective skinning maps with a critical points*.

Certain classes of 3-manifolds, following Thurston, give rise to a ‘skinning map’, a self-map of the Teichmüller space of the boundary. Inspired by numerical evidence of Dumas and Kent, we examine the skinning map of a genus-2 handlebody with two rank-1 cusps. We exploit an orientation-reversing isometry to conclude that the skinning map sends a specified path to itself, and use estimates on extremal length functions to show non-monotonicity and the existence of a critical point. (Received February 10, 2013)

1088-51-208 **Radu A Cebanu*** (radu.cebenu@gmail.com), 35 Beechcroft, Apt. 4, Brighton, MA 02135. *Surgeries between lens spaces and $S^1 \times S^2$* . Preliminary report.

We use Heegaard-Floer Homology to investigate knots in lens spaces which admit longitudinal $S^1 \times S^2$ surgeries. We prove that such knots have generalised Seifert genus 0 and are fibred. When viewed in $S^1 \times S^2$, they are isotopic to braids. We also show that they are Floer simple and we identify the homology classes in which they lie. (Received February 11, 2013)

1088-51-211 **Michel Boileau** (boileau@math.univ-toulouse.fr), , France, **Steven Boyer** (boyer.steven@uqam.ca), , Canada, **Radu Cebanu*** (radu.cebenu@gmail.com), 35 Beechcroft, apt 4, Brighton, MA 02135, and **Genevieve Walsh** (genevieve.walsh@gmail.com), MA. *Commensurability of hyperbolic knot complements*. Preliminary report.

We will present several results concerning commensurability of hyperbolic knot complements in the three-sphere. In the case where the knot complements admit no hidden symmetries, we show that there are at most three knot complements in a commensurability class and provide several necessary topological conditions for a knot complement to be non-unique in its commensurability class. If time allows, we will also discuss briefly the hidden-symmetry case. This is on-going joint work with M. Boileau, S. Boyer and G. Walsh. (Received February 11, 2013)

1088-51-229 **Isabel Hubard, Mark Mixer, Daniel Pellicer and Asia Ivic Weiss*** (weiss@mathstat.yorku.ca). *Polytopes derived from the cubic tessellation of 3-space*.

We consider 4-polytopes arising from a regular tessellation of euclidean 3-space by taking its quotients with a fixed-point-free group of its isometries. (Received February 11, 2013)

52 ► *Convex and discrete geometry*

1088-52-43 **Satyan Devadoss*** (satyan.devadoss@williams.edu) and **Stefan Forcey**. *Realization of Nested Posets*. Preliminary report.

Given a graph G , the graph associahedron KG is a simple polytope whose face poset is based on nested subgraphs of G . This polytope now appears in numerous areas, including Bergman complexes, moduli spaces of curves, phylogenetic rankings, and Seiberg-Witten invariants. For this talk, we broaden the notion of nested subgraphs to nested posets. In particular, given a poset P , we construct a convex polytope KP whose face poset is isomorphic to compatible nestings of P . This naturally extends associativity notions to a far larger class, such as cell complexes. (Received January 24, 2013)

1088-52-76 **Corey M. Manack and Stephen J. Hetterich*** (shetterich15@amherst.edu). *Tiling a Flat Torus*.

This project was motivated by the following question: How can one wallpaper a flat torus? A flat torus is simply a parallelogram with opposite edges identified, and to each wallpaper there is an associated a wallpaper group G . Our original question amounts to describing rank 2 subgroups of the translation subgroup of G . For certain lattice/torus pairs, we found some nice number theoretic properties. For instance, call a flat torus equilateral if it can be cut along its shorter diagonal into two congruent equilateral triangles. We show that n hexagons can be tiled in an equilateral torus if n is the product of powers of 3, squares, or primes congruent to 1 mod 3. Similarly, we show that n squares can be tiled in a square torus if n is a product of powers of 2, squares, or primes congruent to 1 mod 4.

There are several avenues for future research; we will discuss as many as time permits. (Received February 04, 2013)

1088-52-118 **Alexander Kolpakov*** (kolpakov.alexander@gmail.com), Department of Mathematics, Vanderbilt University, 1326 Stevenson Center, Nashville, TN 37240. *Hyperbolic ideal right-angled polytopes, octahedrites and dimension bounds*.

We prove that amongst the ideal right-angled polytopes in the four-dimensional hyperbolic space, the Coxeter 24-cell (realised as one of those) has

- 1) minimal volume,
- 2) minimal facet number.

Moreover, it is uniquely determined by each of the above properties.

The 24-cell may be considered as a four-dimensional analogue to an octahedron, and has octahedral facets. In the proof certain combinatorial descendants of an octahedron, called octahedrites and discovered by M. Deza with co-authors, play an essential role.

We shall also discuss possible dimension bounds for hyperbolic ideal right-angled polytopes based on the results by V. Nikulin and the above fact. (Received February 06, 2013)

1088-52-119 **Marko Boben, Gábor Gévay and Tomaz Pisanski*** (tomaz.pisanski@fmf.uni-lj.si), University of Ljubljana, FMF, 1111 Ljubljana, Slovenia. *Isometric Point-Circle Configurations and Unit-Distance Polycirculants*.

A *polycirculant* is a graph that admits a non-trivial semi-regular automorphism. A *point-circle configuration* is a collection of points and circles in the Euclidean plane, such that each point belongs to the same number of circles, and each circle belongs to the same number of points. If all circles have the same radius, the configuration is called *isometric*. Unit-distance graphs give rise to isometric point-circle configurations. Some unit-distance polycirculants give rise to isometric point-circle configurations that admit rotational symmetry. The question to what extent the theory of polycyclic point-line configurations can be adapted to point-circle configurations is explored. (Received February 06, 2013)

1088-52-124 **Marjorie Senechal*** (senechal@smith.edu), Burton 211, Smith College, Northampton, MA 01063. *Polyhedra, nanoclusters, and crystals*. Preliminary report.

“Tradition ascribes to Plato the discovery of the five regular convex solids . . . and Federov discovered the five parallelehedra.” Thus spoke B. N. Delone, a Russian mathematician with a deep interest in crystallography. Indeed, for a century after Federov’s 1885 discovery, the parallelehedra were the more momentous for crystallography, because they characterize periodic crystal structures.

A century after Federov, the discovery of quasicrystals overthrew the periodicity paradigm. Contemporary crystallographers are focusing on Plato again, modeling condensed matter not by tilings but by packings. In these models, tetrahedra and icosahedra and nanoclusters built with them play key roles. This talk is a survey of some recent developments. (Received February 06, 2013)

1088-52-138 **Daniel Pellicer*** (pellicer@matmor.unam.mx), Melocotonero #171, 58087 Morelia, Michoacan, Mexico, and **Isabel Hubard** and **Javier Bracho**. *Equivelar toroids in the projective space*. Preliminary report.

Maps in the torus with vertices with the same degree and faces with the same co-degree have been known for a long time. It was proved in previous papers that regular maps in the torus of type 4,4 (that is, there are four squares around each vertex) admit realizations on the projective space. Some of these maps admit realizations with planar faces, resembling polyhedra. Others require the faces to be non-planar polygons, while still preserving the combinatorial structure of the map.

In this talk we give in detail the geometry of the realizations of regular maps of type 4,4 on the projective space. Furthermore, we show that all (not necessarily regular) maps in the torus with type 4,4 admit realizations on the projective space. (Received February 07, 2013)

1088-52-142 **Undine Leopold*** (leopold.u@husky.neu.edu). *Vertex-Transitive Polyhedra in 3-Space*. Preliminary report.

In addition to regular and chiral polyhedra, which have been extensively studied, the vertex-transitive polyhedra (uniform in the combinatorial sense) of higher genus also present an attractive and worthwhile challenge. While the definition is combinatorial, the question which I will address is that of realization in Euclidean 3-space as a symmetric, non-selfintersecting polyhedron in the more classical sense (with flat, non-selfintersecting faces). In this talk, I will present an overview of the topic as well as work in progress. (Received February 07, 2013)

1088-52-146 **Dimitri Leemans*** (d.leemans@auckland.ac.nz), Department of Mathematics, Private Bag 92019, Auckland, New Zealand. *Abstract polytopes with O’Nan as automorphism group*.

In this talk, I will present techniques we have developed with Thomas Connor and Mark Mixer to classify all abstract regular polytopes of rank at least 4 having the O’Nan sporadic simple group as full automorphism group.

For the rank three case, I will present a recent algorithm designed by Connor and myself to find bounds on the number of regular and chiral polyhedra using character theory.

The techniques described can be applied to other groups. In particular, I will say a few words about the Lyons sporadic group as well. (Received February 07, 2013)

1088-52-168 **Benjamin T Nill*** (benjamin.nill@case.edu), Math Department, Yost Hall 242, 10900 Euclid Avenue, Cleveland, OH 44106, and **Arnau Padrol**, Dept. MAII, Barcelona, Spain. *From Ehrhart theory to almost-neighborly polytopes.*

A polytope is said to be k -neighborly, if every subset of at most k vertices forms a face. Neighborly polytopes have been objects of intensive study. In this talk I will present some results on polytopes satisfying the following weaker property: every subset of at most k vertices is contained in a facet. These polytopes are called k -almost neighborly. Our research is motivated by recent investigations on an invariant in Ehrhart theory, which is the study of multiples of lattice polytopes (polytopes whose vertices have integer coordinates). There the so-called degree measures the complexity of a lattice polytope without interior lattice points. Much of the acquired intuition can be translated to the combinatorial setting of almost-neighborly polytopes.

This is joint work with Arnau Padrol. (Received February 09, 2013)

1088-52-173 **Mark Mixer*** (mark.mixer@williams.edu), **Daniel Pellicer** and **Gordon Williams**. *Presenting monodromy groups: The Archimedean tilings.*

Recently D. Pellicer and G. Williams constructed presentations for the monodromy groups of three of the Archimedean tilings. However, their construction grows in complexity with the number of flag orbits in the tiling, and the remaining five tilings remained unsolved. In this talk I will discuss a new technique that yields finite presentations of the monodromy groups of all the Archimedean tilings. (Received February 09, 2013)

1088-52-218 **Henry Cohn** (cohn@microsoft.com), **Abhinav Kumar*** (abhinav@math.mit.edu) and **Gregory Minton** (gminton@math.mit.edu). *Existence of tight simplices and other codes in compact spaces.*

A tight simplex (or more generally, code) in a compact 2-point homogeneous space is one which matches the linear programming bound for size, subject to its minimal distance. We will survey known examples of tight codes in real and complex projective spaces, and describe new existence proofs of many families of tight simplices in projective spaces over the quaternions and octonions. (Received February 11, 2013)

1088-52-243 **Anthony Cutler*** (amcutler@msn.com). *Regular Polyhedra of Index 3*. Preliminary report. A regular polyhedron (i.e. one that is flag-transitive on its group of automorphisms) is said to be ‘of index n ’ if its group of symmetries has n flag orbits. Thus the symmetry group is a subgroup of order n of the automorphism group. All finite regular polyhedra of index 1 or 2 have been classified.

We will describe, and briefly analyze, all finite regular polyhedra of index 3. (Received February 11, 2013)

1088-52-283 **Eric L Grinberg*** (eric.grinberg@umb.edu), Department of Mathematics, UMass Boston, Boston, MA 02125. *Integral Geometry on the minimal finite projective space*. Preliminary report.

We discuss analogs of the Radon transform and its associated problems of integral geometry, including uniqueness, inversion, and admissibility in the context of a finite projective space. There are many similarities and many differences with continuous analogs. (Received February 12, 2013)

1088-52-284 **Isabel Hubard***, isahubard@im.unam.mx, and **Javier Bracho** and **Daniel Pellicer**. *Some relations among equivelar 3-toroids*. Preliminary report.

In this talk we revisit the concept of an equivelar 3-toroid and their possible symmetry types. We then move to see some relations between toroids of the same (Schläfli) type that will have important consequences when realizing them in geometric spaces. (Received February 12, 2013)

53 ► Differential geometry

1088-53-46 **Henri Guenancia*** (guenancia@math.jussieu.fr), Institut de Mathématiques de Jussieu, Université Pierre et Marie Curie, 4 place Jussieu, 75005 Paris, France. *Kähler-Einstein metrics on varieties with log-canonical singularities.*

If X is a complex projective manifold with ample canonical bundle K_X , we know since Aubin (1976) that it admits a unique Kähler-Einstein metric having Ricci curvature equal to -1 . We will show how to generalize this result for X being a projective variety with at most log-canonical singularities. This is joint work with Robert Berman. (Received January 28, 2013)

1088-53-50 **Luca Fabrizio Di Cerbo*** (luca@math.duke.edu), Mathematics Department Duke University, Box 90320, Durham, NC 27708-0320, and **Gabriele Di Cerbo**. *Positivity in Kähler-Einstein theory*.

I will show how some questions motivated by the theory of Kahler-Einstein(KE) metrics with singularities can be solved using classical theorems in the minimal model program. For example, I will characterize the pairs which admit KE metrics with negative scalar curvature and small cone-edge singularities along a simple normal crossing divisor. If time permits, I will describe some applications of these results in complex hyperbolic geometry. (Received January 29, 2013)

1088-53-61 **Chi Li*** (chi.li@stonybrook.edu) and **Song Sun**. *Construction of conic Kahler-Einstein metrics*.

I will talk about joint work with Dr. Song Sun. We develop the degeneration-interpolation method for constructing conic Kahler-Einstein metrics. As an application, we prove that Kahler-Einstein metric on P^2 with cone singularities along a smooth degree 2 curve exists if and only if the cone angle is in the interval $(\pi/4, 2\pi]$. When the cone angle is $\pi/3$, this conic Kahler-Einstein metric induces a Calabi-Yau cone metric on 3 dimensional A_2 singularity. This answers a question by Gauntlett-Martelli-Sparks-Yau. (Received January 31, 2013)

1088-53-90 **Alexandra L Femia*** (alfemi130g.holycross.edu), 1 College Street, P.O Box 0973, Worcester, MA 01610. *Modeling Negative Curvature of Beta-Sheet Proteins*.

Proteins are large, complex biological molecules consisting of four layers of structure, which define both their shape and function. The secondary structure includes two distinct and ubiquitous shapes: alpha helices and beta sheets, with alpha helices being slightly more common in the environment. Alpha helices have a fairly regular, right-handed helical structure. Beta-sheets consist of segments of oriented protein strands connected hydrogen bonds, and arranged in parallel or antiparallel oriented sheets. Their shape and orientation depend on the strand information (primary structure), the interaction between strands (secondary structure), and with the environment (tertiary structure). In this project, we extracted information regarding beta strand backbone locations, and corresponding registration information from the Protein Data Bank to analyze the piecewise linear geometry of beta sheets. We developed simplicial surfaces, whose vertex set contains protein backbone atoms. In particular, we analyzed the polyhedral geodesic, mean, and Gaussian curvatures for these simplicial models. As a result, we were able to characterize beta sheets as negatively curved surfaces and give a statistical characterization of their curvature functions. (Received February 04, 2013)

1088-53-98 **Damin Wu*** (damin.wu@uconn.edu), 196 Auditorium Road, Unit 3009, Storrs, CT 06269. *Complete Kahler-Einstein metrics on quasi-projective manifolds revisited*.

It is known that a quasi-projective manifold with ample logarithmic canonical bundle admits a unique complete Kähler-Einstein metric. The asymptotic behavior of the canonical metric has been studied in the literature. In this talk I will present a more precise asymptotic expansion of the canonical metric near the boundary divisor. (Received February 04, 2013)

1088-53-103 **Tamás Darvas*** (tdarvas@math.purdue.edu), 150 N. University Street, West Lafayette, IN 47907-2067. *Regularity of Geodesics in the Space of Kähler metrics*.

Suppose (X, ω_0) is a Kähler manifold. As it was found by Mabuchi, the space of Kähler metrics cohomologous to ω_0 has an infinite dimensional Riemannian manifold structure. Semmes observed that the problem of joining two points in this space with a geodesic is equivalent to a boundary value problem for the complex Monge-Ampère equation. We discuss regularity issues related to this problem. (Received February 05, 2013)

1088-53-112 **Eric Bahuaud***, Department of Mathematics, Seattle University, Seattle, WA. *On the evolution of APEs*. Preliminary report.

The renormalized volume is an important invariant of an even dimensional Poincaré-Einstein manifold. More generally it is possible to define the renormalized volume of an asymptotically Poincaré-Einstein (APE) metric that has a certain expansion at infinity. In this talk I will outline our initial results studying how this quantity evolves under a normalized Ricci flow, and state a monotonicity result for a certain class of APE metrics. This is joint work with Rafe Mazzeo and Eric Woolgar. (Received February 05, 2013)

1088-53-153 **Rafal Komendarczyk*** (rako@tulane.edu), 6823 St. Charles Ave, New Orleans, LA 70118. *Remarks on the asymptotic invariants of divergence free vector fields*. Preliminary report.

I will review the Arnold's construction of the asymptotic linking number for a divergence free vector field on S^3 and indicate some of its interesting consequences. (Received February 08, 2013)

1088-53-235 **Michael F. Atiyah**, School of Mathematics, University of Edinburgh, Mayfield Road, Edinburgh, Scotland EH9 3JZ, United Kingdom, and **Claude R. LeBrun***, Department of Mathematics, SUNY, Z-3651, Stony Brook, NY 11794-3651. *Curvature, Cones, and Characteristic Numbers.*

We study Einstein metrics on smooth compact 4-manifolds with an edge-cone singularity of specified cone angle along an embedded 2-manifold. To do so, we first derive modified versions of the Gauss-Bonnet and signature theorems for arbitrary Riemannian 4-manifolds with edge-cone singularities, and then show that these yield non-trivial obstructions in the Einstein case. We then use these integral formulæ to obtain interesting information regarding gravitational instantons which arise as limits of such edge-cone manifolds. (Received February 11, 2013)

1088-53-260 **Frederick Tsz-Ho Fong*** (fong@math.brown.edu). *Kähler-Ricci Flow on Holomorphic Fibrations.*

In this talk, I will discuss the singularity development of the Kähler-Ricci flow on some holomorphic fibrations, and classify the singularity models using parabolic rescaling.

The first part is a joint work with Zhou Zhang. We study the collapsing behavior of regular Calabi-Yau fibrations under the Kähler-Ricci flow. The flow behavior with possibly singular Calabi-Yau fibers was first studied by Song and Tian, establishing metric convergence in the sense of currents. We focused on the regular case in this work and proved stronger convergence, including smooth convergence in the case where the fibers are complex tori.

The second work studies $\mathbb{C}P^1$ -bundles over Kähler-Einstein manifolds. Song, Székelyhidi and Weinkove proved the Gromov-Hausdorff convergence when the Kähler-Ricci flow collapses the fibers. In this work, I studied the finite-time singularities using parabolic rescaling, classified the singularity model and showed the singularity must be of Type I. (Received February 12, 2013)

55 ► Algebraic topology

1088-55-21 **Ismar Volic*** (ivolice@wellesley.edu), Department of Mathematics, 106 Central St., Wellesley College, Wellesley, MA 02481. *Configuration space integrals in the study of knot and link spaces.*

Inspired by the linking number, Bott and Taubes, following work of Bar-Natan, Kontsevich, and others, defined certain integrals over configuration spaces which produce invariants of classical knots and links as well as higher cohomology classes on spaces of knots and links in Euclidean space of dimension >3 . The main goal of this talk will be to describe this construction and its many interesting and unexpected connections to Vassiliev and Milnor invariants, calculus of functors, and rational homotopy theory. (Received December 16, 2012)

57 ► Manifolds and cell complexes

1088-57-20 **Jeffrey Meier*** (jmeier@math.utexas.edu), 703 Harris Ave, Unit B, Austin, TX 78705. *Seifert fibered surgery on hyperbolic pretzel knots.*

We will discuss the classification of Seifert fibered surgeries on hyperbolic pretzel knots. This is the last step in the classification of exceptional surgeries on hyperbolic pretzel knots. We will also discuss work in progress to complete the last remaining step in the classification of Seifert fibered surgeries on Montesinos knots, which would complete the classification of exceptional surgeries on arborescent knots. (Received January 15, 2013)

1088-57-44 **Satyan Devadoss*** (satyan.devadoss@williams.edu) and **Jack Morava**. *Phylogenetic networks and the real moduli space of curves.*

Our story is motivated by the Deligne-Knudsen-Mumford compactification of the moduli spaces of curves. We consider the real points of these spaces, which have elegant geometric and combinatorial properties, being compact hyperbolic manifolds with a beautiful tessellation by convex polytopes. In recent years, they have gained importance in their own right, appearing in areas such as representation theory, geometric group theory, tropical geometry, and lately reinterpreted as spaces of phylogenetic networks. In particular, these real moduli spaces resolve the singularities of the spaces of phylogenetic trees studied by Billera, Holmes, and Vogtmann. (Received January 24, 2013)

1088-57-45 **Hongbin Sun*** (hongbins@princeton.edu), Department of Mathematics, Princeton University, Fine Hall, Washington Road, Princeton, NJ 08540. *A Transcendental Invariant of Pseudo-Anosov Maps.*

For each pseudo-Anosov map, we will associate it with a \mathbb{Q} -submodule of \mathbb{R} . This invariant is defined by interaction between Thurston norm and dilatation of pseudo-Anosov map. We will develop a few nice properties of our invariant and give a few examples to show it can be nontrivial. These nontrivial examples give negative answer to a question asked by McMullen. (Received January 25, 2013)

1088-57-51 **Jason DeBlois*** (jdeblois@pitt.edu). *The maximal maximal injectivity radius of hyperbolic surfaces.*

For any fixed finite type, I will describe a sharp upper bound on the maximal injectivity radius of finite-area hyperbolic surfaces of that type. For closed surfaces this follows from “Boröczy’s theorem”, but for non-compact surfaces it is more involved. (Received January 29, 2013)

1088-57-57 **Piotr Przytycki** and **Jennifer Schultens*** (jcs@math.ucdavis.edu), Department of Mathematics, University of California, Davis, 1 Shields Ave, Davis, CA 95616. *The Kakimizu complex of a knot.*

We discuss the Kakimizu complex of a knot, define a projection map on the Kakimizu complex of a knot and show how the projection map can be employed to derive topological and geometric information about the Kakimizu complex of a knot. (Received January 30, 2013)

1088-57-66 **Christopher K Atkinson** and **David Futer*** (dfuter@temple.edu), Mathematics Department, Temple University, 1805 North Broad St., Philadelphia, PA 19122. *Small volume link orbifolds.*

I will discuss recent investigations of small volume hyperbolic 3-orbifolds whose singular locus is a link. An orbifold of this type naturally arises as the quotient of a 3-manifold under a (nice) group action. Thus, lower bounds on the volume of these orbifolds lead to relations between the volume of a 3-manifold and the size of its symmetry group.

In this talk, I will describe the unique smallest volume link orbifold whose singular locus is a link in the 3-sphere. I will also identify the unique smallest volume link orbifold whose torsion order is n , for all sufficiently large n . (Received February 01, 2013)

1088-57-67 **Alexander Zupan*** (zupan@math.utexas.edu). *The classification of bridge surfaces for torus knots.* Preliminary report.

It is a classical result of Schubert that the bridge number of a (p,q) -torus knot is the minimum of p and q , while a recent theorem of Ozawa asserts that such knots have a unique irreducible bridge sphere. We extend this result, proving that a torus knot has precisely one irreducible bridge surface of positive genus. (Received February 01, 2013)

1088-57-88 **Jessica E. Banks*** (jessica.banks@lmh.oxon.org). *Minimal genus Seifert surfaces for prime, special alternating links.*

The Kakimizu complex $MS(L)$ of a link L is a simplicial complex that records the structure of the set of minimal genus Seifert surfaces for L considered up to ambient isotopy fixing the link. For non-split links, $M(L)$ has been shown by Przytycki–Schultens to be contractible.

This fact is used in proving a result stated by Hirasawa–Sakuma that gives an explicit description of the Kakimizu complex when L is a non-split, prime special alternating link. Such links have a diagram that is both alternating and special (that is, one where one of the two checkerboard surfaces is a Seifert surface), and the Kakimizu complex is described in terms of this diagram. This shows that every minimal genus Seifert for L is a checkerboard surface for some special alternating diagram for L , and also tells us when two different diagrams yield the same Seifert surface. In this talk we will discuss the statement and proof of this result. (Received February 04, 2013)

1088-57-121 **Peter D Horn***, 215 Carnegie Building, Department of Mathematics, Syracuse, NY 13244-1150. *Computing Higher-order Alexander Polynomials of Knots.* Preliminary report.

The classical Alexander polynomial of a knot can be defined in several ways, one of which is via covering spaces. Using higher covering spaces, Cochran defined the ‘higher-order Alexander polynomials’ It is known that the degree of the classical Alexander polynomial gives a lower bound for the genus of a knot, and so do the degrees of the higher-order Alexander polynomials. These higher-order bounds are known to be stronger than the classical bound for satellite knots, but little is known about low crossing knots. We will present an algorithm to compute

the degree of the first higher-order Alexander polynomial of any knot, and we will discuss some interesting computations. (Received February 06, 2013)

1088-57-125 **Matthew Hedden***, Department of Mathematics, Michigan State University, East Lansing, MI, **Chris Herald**, Department of Mathematics, University of Nevada, Reno, NV, and **Paul Kirk**, Department of Mathematics, University of Indiana, Bloomington, IN.
The pillowcase and perturbations of traceless representations of knot groups.

I'll discuss joint work with Chris Herald and Paul Kirk which aims to explicitly understand the generating sets for Kronheimer and Mrowka's singular instanton chain complexes. A priori, these complexes are not finite, since they count representations of the knot group that typically come in positive dimensional families. I'll show how to explicitly perturb the Morse functional to ensure non-degeneracy, whilst preserving the desirable feature of being able to identify generators in terms of particular representations of the (augmented) knot group. A particular feature which arises in this pursuit, and which is of independent interest, is a computation of the chain groups in terms of Lagrangian intersection pictures occurring in a "pillowcase". Our work suggests the study of tangle invariants from singular instantons. (Received February 06, 2013)

1088-57-136 **Jonathan D Williams*** (jdwm@math.uga.edu). *Surface diagrams and Floer homology.*
Preliminary report.

I will discuss Floer homology groups that are defined using something I call a surface diagram of an arbitrary smooth, closed orientable 4-manifold. (Received February 07, 2013)

1088-57-139 **Genevieve S. Walsh*** (genevieve.walsh@gmail.com), Tufts University Mathematics, 503 Boston Ave, Medford, MA 02155. *Right-angled Coxeter groups and acute triangulations.*

Abstract: Given a (combinatorial) triangulation T of the two-sphere, there is a right-angled coxeter group $C(T)$ which is defined by the one-skeleton of T . When the triangulation T can be realized as an acute triangulation, we show how to build a CAT(-1) polyhedral complex on which $C(T)$ acts geometrically. This space is quasi-isometric to \mathbb{H}^3 . As a corollary, a triangulation of the two-sphere can be realized as an acute triangulation if and only if it does not contain any separating 3- or 4- cycles. This is joint work with Sang-hyun Kim, KAIST. (Received February 07, 2013)

1088-57-166 **Yi Liu*** (yliumath@caltech.edu). *Virtual positivity of representation volumes.*

In this talk, we discuss hyperbolic volume and Seifert volume of closed mixed 3-manifolds. In particular, we show that these volumes are virtually positive if a corresponding geometric piece presents. We construct virtual representations using ingredients from recent work of Przytycki and Wise. This is joint work with Pierre Derbez and Shicheng Wang. (Received February 08, 2013)

1088-57-172 **Sam Aaron Ballas*** (sballas@math.utexas.edu). *Convex Projective Deformations of the Figure-8 Knot Complement.*

Let M be the complement of the figure-8 knot complement. One consequence of Mostow rigidity is that, up to conjugation, there is a unique discrete faithful representation ρ_0 of $\pi_1(M)$ into $SO(3,1)$. However, when we embed $SO(3,1)$ into $PGL(4, \mathbb{R})$ then it is sometimes possible to find families of conjugacy classes of representations into this larger group that pass through ρ_0 . In this talk we will exhibit such a family of representations for $\pi_1(M)$ and show how these representations correspond to interesting geometric structures on M . (Received February 09, 2013)

1088-57-199 **R Sean Bowman*** (sean.bowman@okstate.edu), Department of Mathematics, Oklahoma State University, Stillwater, OK 74078. *Dehn surgery and bridge number of knots in handlebodies.*

I will describe a family of knots in handlebodies which have nontrivial handlebody surgeries. The knots can be obtained by a process called "twisting along an annulus." We'll examine this construction with an eye to approximating the bridge number and, as a result, see that that there are knots in this family with arbitrarily high bridge number. (Received February 10, 2013)

1088-57-210 **Kenneth L Baker*** (k.baker@math.miami.edu), Department of Mathematics, Ungar 515, 1365 Memorial Drive, University of Miami, Coral Gables, FL 33146, and **Cameron Gordon** and **John Luecke**. *Unbounding Bridge Numbers.*

Work in progress gives conditions that ensure a 1-parameter family of knots created by annular twists has unbounded genus g bridge numbers. We'll overview this result and discuss a few applications. (Received February 11, 2013)

- 1088-57-212 **Kristen Hendricks***, hendricks@math.columbia.edu. *Doubly Periodic Knots and Link Floer Homology.*
 A q -periodic knot is a knot $\tilde{K} \subset S^3$ preserved by an orientation-preserving action of \mathbb{Z}_q on S^3 whose fixed set is an unknot disjoint from \tilde{K} . We discuss how two classical results on the geometry of periodic knots, Murasugi's condition on the Alexander polynomial and Edmonds' condition on the genus, may in the case of 2-periodic knots be simultaneously generalized using spectral sequences in the modern invariant link Floer homology. (Received February 11, 2013)
- 1088-57-214 **Robert Lipshitz, Lenhard Ng and Sucharit Sarkar*** (sucharit@math.princeton.edu). *On the Plamenevskaya invariant.*
 I will discuss two refinements of Plamenevskaya's transverse invariant in Khovanov homology and show that one of them is invariant under negative flypes. This work is joint with Robert Lipshitz and Lenny Ng. (Received February 11, 2013)
- 1088-57-215 **Keiko Kawamuro*** (kawamuro@iowa.uiowa.edu), 14 MacLean Hall, Iowa City, IA 52242. *Open book foliation and fractional Dehn twist coefficients.*
 I will describe relationship between open book foliation and the fractional Dehn twist coefficient and show applications. This is joint work with Tetsuya Ito. (Received February 11, 2013)
- 1088-57-219 **Cagri Karakurt, Tye Lidman*** (tlid@math.utexas.edu) and **Ciprian Manolescu.** *Floer homology and non-zero degree maps.* Preliminary report.
 We study rank inequalities for Heegaard and monopole Floer homology groups under some different non-zero degree maps. This includes regular covers with solvable deck transformation group and cyclic branched covers of Brieskorn spheres. This is joint work with Cagri Karakurt and separately with Ciprian Manolescu. (Received February 11, 2013)
- 1088-57-221 **Matthew Hedden and Thomas E. Mark*** (tmark@virginia.edu), PO Box 400137 Kerchof Hall, Department of Mathematics, University of Virginia, Charlottesville, VA 22904. *Open books, twist numbers, and Floer homology.*
 An open book decomposition of a 3-manifold Y is essentially the choice of a fibered link embedded in Y . For a fibered knot (i.e. a one-component link), the monodromy of the fibration on the complement gives rise to a rational number called the fractional Dehn twist coefficient. This number measures the twisting of the monodromy around the boundary of the fiber surface. I will describe how the Heegaard Floer homology of Y provides bounds for the fractional Dehn twist coefficient of any open book decomposition of Y having connected binding, and discuss applications to knot theory and contact topology. This is joint work with Matthew Hedden. (Received February 11, 2013)
- 1088-57-227 **Stanislav Jabuka*** (jabuka@unr.edu), Department of Mathematics and Statistics, University of Nevada, Reno, NV 89557, and **Swatee Naik** (naik@unr.edu), Department of Mathematics and Statistics, University of Nevada, Reno, NV 89557. *Periodic knots and Heegaard Floer homology.*
 The study of periodic knots is a natural extension of the usual framework of knot theory to the equivariant case. Focusing on finite cyclic group actions, we say that a knot in the 3-sphere has period $p > 1$ if there is an action of the cyclic group of p elements on the 3-sphere (by orientation preserving diffeomorphisms) that preserves the knot set wise. Given a knot K , the main question is to determine if K admits any periods and if so, what is a complete list of such periods.
 There are many classical obstructions to periodicity of a knot, involving for instance the Alexander polynomial of a knot or the homology groups of the knot's various cyclic branched coverings. We shall present a new obstruction to periodicity coming from Heegaard Floer homology, relying chiefly on the Heegaard Floer correction terms. We will give examples of knots for which classical obstructions of periodicity vanish but for which the Heegaard Floer obstructions do not. (Received February 11, 2013)
- 1088-57-244 **Jennifer Hom*** (hom@math.columbia.edu), **Sam Lewallen, Tye Lidman and Liam Watson.** *The Seifert form, Alexander module, and bordered Floer homology.* Preliminary report.
 Abstract: We study the bordered Floer homology of the 3-manifold with boundary obtained by cutting S^3 along a Seifert surface Σ for a knot K . In particular, we show that this bordered invariant determines both the Seifert form and Alexander module. This is joint work in progress with Sam Lewallen, Tye Lidman and Liam Watson. (Received February 11, 2013)

1088-57-246 **David T Gay*** (dgay@uga.edu), Mathematics Department, University of Georgia, Athens, GA 30606, and **Robion Kirby**. *Trisections of 4-manifolds*.

A trisection of a 4-manifold is a decomposition into 3 pieces, each a boundary connected sum of $S^1 \times B^3$'s, intersecting pairwise along 3-dimensional handlebodies, with triple intersection a surface. Trisections are unique up to a natural stabilization operation. This is completely analogous to the situation with Heegaard splittings of 3-manifolds. I will outline the proofs of existence and uniqueness. (Received February 11, 2013)

1088-57-256 **Liam Watson*** (lwatson@math.ucla.edu). *Heegaard Floer homology and the Alexander trick*.

An immediate consequence of the Alexander trick is that a Dehn twist along the torus meridian extends to a homeomorphism of the solid torus. This property characterizes the solid torus among irreducible, orientable 3-manifolds with torus boundary, a fact that follows from Johannson's finiteness theorem. This no longer holds at the level of Heegaard Floer homology. In particular we'll construct, and study the bordered Floer invariants of, infinite families of what might be termed Heegaard Floer homology solid tori. This will require a close look at certain bimodules associated with cable spaces. (Received February 12, 2013)

1088-57-261 **Thomas C Jaeger*** (tcjaeger@syr.edu), Mathematics Department, 215 Carnegie Building, Syracuse University, Syracuse, NY 13244. *The characteristic-2 Rasmussen invariant and mutation*. Preliminary report.

We show that a characteristic-2 version of Rasmussen's s -invariant, which is implicit in the work of Turner and has recently been shown by Lipshitz and Sarkar to be a concordance invariant, does not change under mutation. (Received February 12, 2013)

1088-57-262 **Tye Lidman, Robert Lipshitz, Sucharit Sarkar and David Shea Vela-Vick*** (shea@math.lsu.edu). *Transverse knots, infinite cyclic covers and Heegaard Floer homology*. Preliminary report.

I will discuss a new invariant of transverse knot and links coming from Heegaard Floer theory. Our invariant takes the form of a $Z[t, t^{-1}]$ -module and is obtained by associating a suitable version of Heegaard Floer theory to the infinite cyclic cover of a given transverse knot. In this talk, I plan to show how one defines this invariant and discuss some of its associated properties. (Received February 12, 2013)

1088-57-279 **Loring Tu*** (loring.tu@tufts.edu), Department of Mathematics, Tufts University, Medford, MA 02155. *Raoul Bott's later work on physics-inspired mathematics*. Preliminary report.

In his later years Raoul Bott was interested in bridging the gap between mathematics and physics, and many of his later papers were on mathematics inspired by physics. I will discuss some of his work on manifold invariants, concentrating on the period after 1990. (Received February 12, 2013)

1088-57-280 **Margaret Doig*** (mdoig@indiana.edu). *Obstructing finite surgery*.

For a fixed p , there are only finitely many elliptic manifolds given by p/q -surgery. We prove this result by using the Heegaard Floer correction terms or d -invariants to obstruct elliptic manifolds (which are L -spaces) from arising as knot surgery. (Received February 12, 2013)

1088-57-289 **Christian K Zickert*** (zickert@math.umd.edu), 10101 Baltimore Ave 1307, 10101 Baltimore Ave 1307, College Park, MD 20740. *Thurston's gluing equations for $PGL(n, C)$* .

Thurston's gluing equations are polynomial equations invented by Thurston to explicitly compute hyperbolic structures or, more generally, representations in $PGL(2, C)$. This is done via so called shape coordinates. We generalize the shape coordinates to obtain a parametrization of representations in $PGL(n, C)$. We give applications to quantum topology, and discuss an intriguing duality between the shape coordinates and the Ptolemy coordinates of Garoufalidis-Thurston-Zickert. The shape coordinates and Ptolemy coordinates can be viewed as 3-dimensional analogues of the X - and A -coordinates on higher Teichmüller spaces due to Fock and Goncharov. (Received February 13, 2013)

58 ► *Global analysis, analysis on manifolds*

1088-58-4 **Yanir A Rubinstein*** (yanir@umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *Geometry: (very) local meets global*.

In the study of geometric structures on manifolds, a well-known phenomenon is the intimate interplay between global and local properties of the geometry. Somewhat less classical, and much more recent, is the intriguing

interplay between global and microlocal properties of such structures. We illustrate these phenomena with some particular examples that suggest that such behavior could be ubiquitous in geometry. (Received February 08, 2013)

1088-58-79 **Michael Singer*** (michael.singer@ucl.ac.uk), Department of Mathematics, University College London, Gower Street, London, WC1E 6BT, United Kingdom, and **Richard B Melrose** (rjm@math.mit.edu), Department of Mathematics, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA MA02139. *Smooth gluing theorems for Kähler metrics.*

The problem of finding Kähler metrics of constant scalar curvature (henceforward cscK metrics) on the blow-up \tilde{M} in a collection of points of a compact Kähler manifold which already has such a metric ω is important from the point of view of producing new examples and in relation to the fundamental question about the relation between K-stability and existence of cscK metrics. A number of ‘blow-up theorems’ asserting the existence of cscK metrics on \tilde{M} are now available, due to the work of Arezzo, Pacard, and independently, Székelyhidi.

In the present work, a new approach to this problem is proposed which gives much more precise information about the cscK metrics constructed on \tilde{M} and in particular their dependence on the parameter ϵ which determines the size of the exceptional divisor(s) in \tilde{M} . Indeed, it is shown that there is a 1-parameter family of such metrics $\tilde{\omega}(\epsilon)$ on \tilde{M} which is essentially smooth in ϵ down to $\epsilon = 0$. Geometric microlocal methods and concepts are used, in particular conormal distributions on manifolds with corners. (Received February 04, 2013)

1088-58-99 **Iosif Polterovich** (iossif@dms.umontreal.ca) and **David A. Sher*** (david.sher@mail.mcgill.ca). *Heat invariants of the Steklov eigenvalue problem.* Preliminary report.

We study the heat invariants associated to the Steklov eigenvalue problem on a Riemannian manifold with boundary. Using the Seeley calculus, we prove a general structure theorem for these invariants. We also compute the first few heat invariants explicitly, which identifies several new Steklov spectral invariants. In particular, we prove that the total mean curvature is a Steklov spectral invariant whenever the dimension of the manifold is at least 3. As an application, we prove global Steklov spectral rigidity for a ball in \mathbb{R}^3 : if a compact domain in \mathbb{R}^3 with simply connected boundary has the same Steklov spectrum as a ball, then it is a ball. This is joint work with I. Polterovich (Université de Montréal). (Received February 04, 2013)

1088-58-281 **P. Robert Kotiuga*** (prk@bu.edu), Dept. of Electrical and Computer Engineering, Boston, MA 02215. *Massey products, imperfect Morse functions and micromagnetic exchange energy.* Preliminary report.

Massey products are higher order operations in the cohomology ring of a manifold. Nontrivial products form a set of obstructions to Sullivan formality in rational homotopy theory. This talk outlines situations where, for dimensional reasons, secondary and higher cohomology operations (in both ordinary and generalized cohomology theories) are likely to play a key role, and considers two aspects of critical point theory: 1) Finding practical sufficient conditions ensuring the nonexistence of a perfect Morse function on a given manifold. 2) The use of Massey products and rational homotopy theory in the context of minimizing micromagnetic exchange energy. (Received February 12, 2013)

60 ► Probability theory and stochastic processes

1088-60-3 **Alice Guionnet*** (guionnet@math.mit.edu), Department of Mathematics, MIT, 77 Massachusetts Avenue, Cambridge, MA 02139-430. *The spectrum of non-normal random matrices.*

We shall consider non-normal matrices, that is matrices which do not commute with their adjoint. Such matrices are well-known to have an unstable spectrum. However, we shall see that the spectrum of random non-normal matrices often behaves more nicely. A well known example of non-normal random matrices is simply given by a square matrix with independent and equidistributed entries. It was shown in a series of papers by Girko, Bai and culminating with a work by Tao and Vu, that the spectrum of such matrices is asymptotically distributed according to the uniform measure on the disc. In this talk, we will discuss the properties of the spectrum of more general non-normal random matrices. (Received February 12, 2013)

1088-60-11 **Xin Li*** (xl2206@columbia.edu) and **Tim Leung** (tl2497@columbia.edu). *An Optimal Timing Approach to Mean-Reversion Trading.*

This paper studies the optimal entry and exit timing for trading under mean reversion. This leads to the formulation and analysis of a number of double optimal stopping problems with constraints under time-homogeneous diffusions, including Ornstein-Uhlenbeck, exponential Ornstein-Uhlenbeck, and Cox-Ingersoll-Ross price processes. We rigorously derive the optimal price levels for entry and exit respectively, and examine their dependence on various model parameters such as mean-reversion level and transaction cost. We further analyze the trading problem under a minimal holding period, as well as stop-loss and risk penalty. Numerical results are provided to illustrate the optimal strategies. (Received November 04, 2012)

1088-60-12 **Tim Leung*** (leung@ieor.columbia.edu), New York, NY 10027, and **Ronnie Sircar**. *Implied Volatility of Leveraged ETF Options.*

This paper studies the problem of understanding implied volatilities from options written on leveraged exchanged-traded funds (LETFs), with an emphasis on the relations between options on LETFs with different leverage ratios. We first examine from empirical data the implied volatility surfaces for LETFs based on the S&P 500 index, and we introduce the concept of moneyness scaling to enhance their comparison with non-leveraged ETF implied volatilities. Under a multiscale stochastic volatility framework, we apply asymptotic techniques to derive an approximation for both the LETF option price and implied volatility. The approximation formula reflects the role of the leverage ratio, and thus allows us to link implied volatilities of options on an ETF and its leveraged counterparts. We apply our result to quantify matches and mismatches in the level and slope of the implied volatility skews for various LETF options using data from the underlying ETF option prices. This reveals some apparent biases in the leverage reflected in the different products, long and short with leverage ratios two and three times. (Received November 10, 2012)

1088-60-94 **Xiang Yu*** (xymath@umich.edu), **Erhan Bayraktar** and **Yuchong Zhang**. *Optimal Consumption with Transaction Cost and Random Endowment: Shadow Prices and Connections to Duality.* Preliminary report.

We study the continuous time optimal consumption problem with both proportional transaction cost and random endowment. We discuss the connection between the duality theory and the existence of shadow prices. By treating the initial capital x and the number of shares of random endowments q as both variables of the primal value function, we allow different choices of x and q in the shadow market and provide sufficient conditions such that the optimal consumption policies coincide. Joint work with Erhan Bayraktar and Yuchong Zhang. (Received February 04, 2013)

1088-60-96 **Matthew Lorig*** (mlorig@princeton.edu), ORFE DEPARTMENT, PRINCETON UNIVERSITY, SHERRERD HALL, ROOM 116, Princeton, NJ 08544. *Implied volatility for general local-stochastic volatility models.*

For general local-stochastic volatility models, we derive an implied volatility expansion which captures the ATM level, slope, and convexity of implied volatility. We test our expansion on one local volatility model (CEV) one stochastic volatility model Heston) and one local-stochastic volatility model (SABR). (Received February 04, 2013)

1088-60-131 **Kontantinos Spiliopoulos*** (kspiliop@bu.edu), Department of Mathematics and Statistics, Boston University, 111 Cummington Mall, Boston, MA 02215, and **Kay Giesecke** and **Richard Sowers**. *Most Likely Path to Systemic Failure.*

In this talk, I will present recent results on modeling the dynamics of correlated default events in the financial market. An empirically motivated system of interacting point processes is introduced and we study how different types of risk, like contagion and exposure to systematic risk, compete and interact in large-scale systems. Large deviation arguments are used to approximate the tail of the default loss in large portfolios and to identify the way that atypically large (i.e. ‘rare’) default clusters are most likely to occur. The results give insights into how different sources of default correlation interact to generate atypically large portfolio losses. (Received February 06, 2013)

1088-60-147 **Yu-Jui Huang*** (jayhuang@umich.edu) and **Erhan Bayraktar**. *Robust Maximization of Asymptotic Growth under Covariance Uncertainty.*

This paper resolves a question proposed in Kardaras and Robertson (2012): how to invest in a robust growth-optimal way in a market where precise knowledge of the covariance structure of the underlying assets is unavailable. Among an appropriate class of admissible covariance structures, we characterize the optimal trading strategy in terms of a generalized version of the principal eigenvalue of a fully nonlinear elliptic operator and its

associated eigenfunction, by slightly restricting the collection of non-dominated probability measures. (Received February 08, 2013)

1088-60-157 **Rohini Kumar*** (rkumar@math.wayne.edu). *Effect of volatility clustering on indifference pricing of options by convex risk measures.*

An indifference pricing of options by convex risk measures was developed by Sircar and Sturm in the paper “From smile asymptotics to market risk measures”. In this pricing method, the option price is given as the solution of backward stochastic differential equations. We look at the effect of volatility clustering on this indifference pricing of options. Volatility clustering is modeled by fast mean-reverting volatility in stochastic volatility models for stock price. Asymptotics of the indifference price of options and their corresponding implied volatility are obtained as the mean-reversion time parameter approaches zero. A correction term to the asymptotic option price and implied volatility are also obtained. (Received February 08, 2013)

1088-60-188 **Paolo Guasoni** and **Gu Wang*** (guwang@bu.edu), 111 Cummington Mall, Department of Mathematics and Statistics, Boston University, Boston, MA 02215. *Consumption in Incomplete Markets.*

An agent maximizes isoelastic utility from consumption with infinite horizon in an incomplete market, in which state variables are driven by diffusions. We first provide a general verification theorem, which links the solution of the Hamilton-Jacobi-Bellman equation to the optimal consumption and investment policies. To tackle the intractability of such problems, we propose approximate policies, which admit an upper bound, in closed-form for their utility loss. These policies are optimal for an artificial complete market, in which the safe rate and the state variable follow different dynamics, but excess returns remain the same. The approximate policies have closed form solutions in common models, and become optimal if the market is complete, or utility is logarithmic. (Received February 10, 2013)

1088-60-194 **A. Papapanicolaou***, Sherrerd Hall, Charlton street, Princeton, NJ 08544, and **R. Sircar** (sircar@princeton.edu), Sherrred Hall, Charlton street, Princeton, NJ 08544. *A Regime-Switching Heston Model for VIX and S&P 500 Implied Volatilities.*

Volatility products have become popular in the past 15 years as a hedge against market uncertainty. In particular, there is growing interest in options on the VIX volatility index. A number of recent empirical studies examine whether there is significantly greater risk premium in VIX option prices compared with S&P 500 option prices. We address this issue by proposing and analyzing a stochastic volatility model with regime switching. The basic Heston model cannot capture VIX implied volatilities, as has been documented. We show that the incorporation sharp regime shifts can bridge this shortcoming. We take advantage of asymptotic and Fourier methods to make the extension tractable, and we present a fit to data, both in times of crisis and relative calm, which shows the effectiveness of the regime switching. (Received February 10, 2013)

1088-60-196 **Scott P Robertson*** (scottrob@andrew.cmu.edu), Department of Mathematical Sciences, Wean Hall 6113, Pittsburgh, PA 15213. *Static Fund Separation of Long Term Investments.*

In this talk we will prove a class of static fund separation theorems, valid for investors with a long horizon and constant relative risk aversion, and with stochastic investment opportunities. An optimal portfolio decomposes as a constant mix of a few preference-free funds, which are common to all investors. The weight in each fund is a constant that may depend on an investor’s risk aversion, but not on the state variable, which changes over time. Vice versa, the composition of each fund may depend on the state, but not on the risk aversion, since a fund appears in the portfolios of different investors. We prove these results for two classes of models with a single state variable, and several assets with constant correlations with the state. In the linear class, the state is an Ornstein-Uhlenbeck process, risk premia are affine in the state, while volatilities and the interest rate are constant. In the square root class, the state follows a square root diffusion, expected returns and the interest rate are affine in the state, while volatilities are linear in the square root of state. (Received February 10, 2013)

1088-60-228 **Yildiray Yildirim*** (yildiray@syr.edu), 721 University Ave, Syracuse, NY 13244, and **Thomas Emmerling** and **Abdullah Yavas**. *On Optimal Acceptance Policies in Real Estate.*

This paper considers a full-information variation of the classical secretary problem from probability theory applied to the optimal selling problem in real estate. Here, we analyze the problem of finding the optimal selling policy under the situation when the first bid is distributionally different from subsequent bids and the total number of bids has an unknown distribution. In real estate markets, it is often observed that first offers for real estate tend to be larger than bids which follow. Our aim is to consider this phenomenon within a practical probabilistic framework which incorporates the realistic assumption that the total number of offers for the real

estate is unknown. Mathematically, this represents a slight variation of the full-information best choice problem analyzed by [?]. We identify the optimal selling strategy using the technique of [?] and general optimal stopping theory. Afterwards, we carry out several numerical examples highlighting results pertaining to the likelihood of receiving the largest offer for selling the real estate and the optimal number of bids seen by the seller. (Received February 11, 2013)

1088-60-257 **Roger Lee*** (rogerlee@math.uchicago.edu). *Vanilla-like Options.*

We develop pricing formulas and approximations for some types of options similar to plain vanilla options, such as timer options which expire at the random time when realized variance reaches a specified target. Our approaches are applicable in various families of models. (Received February 12, 2013)

1088-60-265 **Dan Ren*** (dren@bu.edu), MA 02215, and **Paolo Guasoni.** *Loss Aversion and Retirement Planning.* Preliminary report.

We consider an optimal consumption and investment problem, with a representative agent who is more sensitive to declines than to increases in consumption, and investment opportunities are constant.

We solve the resulting free-boundary problem in closed form, using a combination of stochastic control and duality methods. Briefly, the optimal consumption remains constant over long intervals, increases gradually as wealth is high relative to its current consumption, and falls below its last recorded maximum when wealth is low. (Received February 12, 2013)

1088-60-270 **Maxim Bichuch*** (mbichuch@princeton.edu) and **Paolo Guasoni** (guasoni@bu.edu). *Gresham's Law for Liquidity.*

We solve the portfolio choice problem for an investor with a long horizon, and constant relative risk aversion, who trades in a market with safe and risky liquid assets, plus an illiquid asset, which incurs constant proportional transaction costs. If the illiquid asset is highly correlated to another liquid risky asset, the investor optimally increases exposure to the illiquid asset, and decreases exposure to the liquid asset. Thus, a version of the Gresham's law holds: the illiquid asset drives out the liquid asset. We discuss this counter-intuitive result and its explanation. Joint work with Paolo Guasoni. (Received February 12, 2013)

62 ► *Statistics*

1088-62-176 **Michael Carlisle** (mcarlisle@gc.cuny.edu), One Bernard Baruch way, 6th floor, Room 6-230, New York, NY 10010, and **Olympia Hadjiliadis*** (ohadjiliadis@brooklyn.cuny.edu), 365 fifth ave, Department of Mathematics, room 4208, New York, NY 10016. *TWO-DIMENSIONAL SEQUENTIAL HYPOTHESIS TESTING IN THE BROWNIAN MOTION MODEL.*

We consider the problem of a two-dimensional sequential hypothesis test in which we attempt to distinguish between four states of a two-sensor system, each corresponding to a distinct hypothesis H_{ij} , where the index i is equal to zero if no signal is received on the first sensor or one if a signal is received, and likewise for j zero or one on the second sensor. We set up the problem as a min-max optimization in which we wish to find a decision rule that minimizes the length of continuous observation time required to make a decision about the state of the system subject to the error probabilities α_{ij} , each of which stands for the probability of falsely deciding that H_{ij} is the correct hypothesis. We refer to the α_{ij} as the Type ij errors.

We assume that the noise in the two sources of observations is uncorrelated, and propose running in parallel two sequential probability ratio tests each characterized by two thresholds. We compute these thresholds in terms of each of the error probabilities. We demonstrate asymptotic optimality of the proposed rule as the error probabilities decrease without bound and discuss the case of non-zero correlation across channels. (Received February 09, 2013)

65 ► *Numerical analysis*

1088-65-82 **Jay A. Stotsky*** (jay.stotsky@tufts.edu). *Solving the Diffusion Equation on the Sphere with the Finite Element Method and Multigrid Solvers.* Preliminary report.

We have developed an efficient method of solving the diffusion equation on the surface of a sphere using the Finite Element Method to discretize space and the Trapezoid Method to discretize time. A multigrid algorithm was used to solve the large system of linear equations arising in each time step. This is a challenging problem because there is no perfectly regular discretization of the sphere that involves more than 20 points. This complicates the

computation of mass and stiffness matrices and multigrid operators. Using efficient techniques to calculate the multigrid operators and a (2,1)-v-cycle, our method of solving the diffusion equation yields a convergence factor of around 0.175 per iteration and involves a computational effort that is linearly proportional to the number of grid points.

Additional research is being done to apply adaptive mesh refinement and the Fast Adaptive Composite-Grid Method to this problem. In particular, a Finite Element Method based approach to the Fast Adaptive Composite-Grid Method is being developed because of the natural way in which a Fast Adaptive Composite-Grid solver can be derived from a Finite Element Method discretization. Applications of this research can be found in the modeling of radiation beams and in climate models. (Received February 04, 2013)

68 ► *Computer science*

1088-68-70 **Michael J. Pettinati*** (mjp Pett13@g.holycross.edu) and **Constance Royden.**
Computing the Trajectory of Moving Objects Using a Neural Model.

As an observer moves, the points projected onto his/her retina shift. The displacement of these points creates a flow pattern. An observer moving straight, through a static scene, generates a radial pattern with a center corresponding to the observer's direction of motion ("heading"). The center is lost with observer rotation and motion subtraction must be used to recover the heading. This motion subtraction may be done by cells in the medial temporal (MT) area of the brain. MT projects to the medial superior temporal (MST) area of the brain where cells respond to radial patterns of motion and compute heading. A computer model based on MT and MST has been created to compute heading (Royden, 1997). A moving object breaks the radial pattern that MT projects to MST in the case of a static scene; a moving object can be identified by this distinctive region (Royden, 2002). The difference vectors at the object borders contain information about observer and object motion. We found that with information taken from the flow field alone, one can compute relative object motion direction. We added this computation to the computer model, which predicts the object trajectory accurately for certain object angles. Supported by NSF grant IOS-0818286 (Received February 02, 2013)

1088-68-86 **Laura M. Webber***, lmwebb13@g.holycross.edu, and **Constance Royden.** *Using Motion and Disparity Tuning to Detect Moving Objects.*

The goal of this research is to use a computational model of the human visual system to more accurately detect moving objects in a scene. When an observer moves through a scene, the velocities of the images on the retina of the objects in the scene form an optic flow field. One way a moving object can be detected from this flow field is to compare the speed of the velocity vectors of the moving object to the speed of the other velocity vectors. However, more information about the object's depth is needed to make this comparison because of motion parallax; images of objects closer to us move faster on our retinas than images of more distant objects. Therefore, depth information, incorporated using binocular stereo, is necessary. We calculated the binocular disparity of each point in the scene, and tuned each disparity through a cosine squared equation in order to find the maximum difference response. I plotted these responses with the velocity difference responses along the borders of stationary objects at various distances from the observer. I found that the disparity and velocity difference responses form an approximately linear relationship, which can be used to detect moving objects. I thank Alumni/Parent Summer Research Fellowship, Dan Kennedy '68 for financial support. (Received February 04, 2013)

81 ► *Quantum theory*

1088-81-202 **Iana I Anguelova*** (anguelovai@cofc.edu), College of Charleston, Department of Mathematics, Charleston, SC 29424. *Hopf-algebraic tools in quantum and twisted vertex algebras.* Preliminary report.

The theory of quantum and twisted vertex algebras is quite technical, with examples usually presented in terms of generating quantum fields (vertex operators), their operator product expansions (singularities) and R-commutation relations. In this talk I will describe an alternative way to treat examples, based on a triple (H, M, r) , where M is an underlying Hopf algebra, H is another Hopf algebra representing the group of symmetries, and r is a bicharacter. This alternative description is very useful: there are general formulas for the analytic continuations, normal ordered products, vacuum expectation values based on the triple (H, M, r) , formulas which

are much harder or impossible to obtain from the operator-based description. Moreover this alternative point of view allows one to construct very important new examples, e.g., different boson-fermion and particle correspondences. In this talk I will provide a "dictionary" relating the two descriptions. (Received February 10, 2013)

1088-81-258 **Titus Neupert*** (titus.neupert@psi.ch), **Claudio Chamon** and **Christopher Mudry**. *Topology and quantum geometry in flat electronic bands.*

Interacting electrons populating spectrally flat bands are an interesting playground to obtain strongly correlated topological states in condensed matter physics. While the fractional quantum Hall effect of electrons in a strong magnetic field is the most prominent example of such a state, I will discuss a wider class of systems called fractional Chern insulators and fractional topological insulators that became a focus of intense research recently. These exotic many-body states are the result of a subtle interplay of topology and energetics, arising from the noncommutative quantum geometry that electrons experience despite the spectral flatness of the band. I will show how algebraic properties of the electronic position and density operators are determined by the Berry curvature and the quantum metric of single-particle states and how these quantities influence, respectively, the topological response and the energetics of the many-body state. (Received February 12, 2013)

86 ► *Geophysics*

1088-86-54 **Bogdan G Nita*** (nitab@mail.montclair.edu), Department of Mathematical Sciences, Montclair State University, Montclair, NJ 07043, and **Catherine Wilshusen** and **Marcus Jeffrey**. *Examining a Seismic Imaging Algorithm With Band Limited Data.*

One of the biggest difficulties in current seismic imaging methods is the lack of low frequencies in the collected data. In this talk we present a one dimensional inverse scattering algorithm for geophysical imaging and amplitude correction from measured data. We investigate this algorithm numerically using band limited data which is missing zero and low frequency information. Our examples show excellent results in finding both the location of interfaces and the amplitude of acoustic reflections. (Received January 30, 2013)

90 ► *Operations research, mathematical programming*

1088-90-91 **Zhen Huang*** (zhuang@otterbein.edu), Department of Mathematical Sciences, Otterbein University, 1 South Grove Street, Westerville, OH 43081, and **Zengxiang Tong** (ztong@otterbein.edu), Department of Mathematical Sciences, Otterbein University, 1 South Grove Street, Westerville, OH 43081. *Portfolio Selection with Downside Risk and Upside Potential*. Preliminary report.

This paper uses the possibility distribution to model the rate of return in portfolio selection problem. The expected rate of return, downside risk, upside potential for a possibilistic rate of return variable are discussed. Two portfolio selection models with downside risk and upside potential are proposed. First model is a linear programming problem used to maximize the upside potential of the portfolio while requiring the return from the portfolio in an accepted level and controlling the downside risk of the return of portfolio in a tolerable level. Second model is a multi-objective linear programming problem used to maximize the return of the portfolio and to maximize the upside potential of the portfolio while controlling the downside risk of the return of portfolio in a tolerable level.

Key words: Portfolio selection, possibility distribution, downside risk, upside potential, linear programming, and multi-objective linear programming (Received February 04, 2013)

1088-90-156 **Patrick Cheridito** (dito@princeton.edu), Department of Operations Research & Financial Engineering, Princeton, NJ 08544, and **Tardu S Sepin*** (tsepin@princeton.edu), Department of Operations Research & Financial Engineering, Princeton, NJ 08544. *Optimal execution under stochastic volatility and liquidity.*

We study the problem of optimally liquidating a financial position in a discrete-time model with stochastic volatility and liquidity. We provide solutions that minimize the expectation, mean-variance and expected exponential of the cost of liquidation. (Received February 08, 2013)

91 ► *Game theory, economics, social and behavioral sciences*

1088-91-159 **Rodolfo Prieto*** (rprieto@bu.edu), Boston University, Department of Finance, School of Management, 595 Commonwealth Ave., Boston, MA 02215, and **Julien Hugonnier**. *Arbitrageurs, bubbles, and credit conditions*.

We study a pure exchange economy populated by three types of agents: constrained agents who are subject to a risk constraint, unconstrained agents who are only subject to a standard nonnegative wealth constraint, and arbitrageurs who, in addition to being unconstrained, may incur transitory losses that are bounded by a state-dependent credit limit. This uncollateralized credit facility is valuable when there are bubbles, which arise endogenously due to the presence of constrained agents. Since arbitrageurs are required to hold less collateral than other agents, their presence implies a reduction in the value of the stock's collateral services and therefore a decrease in the relative size of the bubble. In contrast to previous results in the literature, we show that the presence of risky arbitrage trading has an impact on the stock price level and makes it more volatile than the underlying fundamental, particularly in bad times, thereby generating the leverage effect. (Received February 08, 2013)

1088-91-165 **Victoria Steblovskaya*** (vsteblovskay@bentley.edu), MA, and **Norm Josephy** and **Lucy Kimball**. *Optimal Hedging in a Discrete Time Incomplete Market with Transaction Costs*. Preliminary report.

Over the last decades, a variety of approaches to pricing and hedging financial derivatives in imperfect markets (in particular, in markets with transactions costs) have appeared in the literature. In [1], within the Cox-Ross-Rubinstein binomial model with proportional transactions costs, the author constructs self-financing replicating strategies that satisfy both a primary no-arbitrage condition and secondary optimality condition on the set-up cost of a hedging portfolio.

We generalize the binomial model considered in [1] to the case where stock price ratios are distributed over a bounded interval. Within this extended binomial model with proportional transactions costs, we build an algorithm that chooses an optimal non-self-financing trading strategy from the set of admissible (market calibrated) trading strategies based on optimization criteria relevant to the investor.

Along with theoretical description of our model and algorithm, encouraging numerical results will be presented.

[1] M. Rutkowski, Optimality of replication in the CRR model with transaction costs, *Applicationes Mathematicae* 25,1 (1998), 29-53. (Received February 08, 2013)

92 ► *Biology and other natural sciences*

1088-92-77 **Craig M. Corsi*** (cmc3@williams.edu), 2687 Paresky Center, 39 Chapin Hall Drive, Williamstown, MA 01267. *Folding Spaces of Phylogenetic Trees*. Preliminary report.

A central problem in mathematical biology is the method of producing a phylogenetic tree (a particular type of edge-weighted, labeled tree graph) which best models a set of numerical biological data. At times only a set of partial trees can be constructed; the goal of approximating or averaging these trees by a single tree motivates the study of continuous spaces whose points correspond to trees. We examine a surjective map between two continuous, real-valued spaces of phylogenetic trees: a compactification of the Billera-Holmes-Vogtmann space BHV and the edge-product space of trees EP. We express this map as a composition of two maps. The inner map is based on a combinatorial equivalence relation defined on trees. The outer map collapses entire subcomplexes to points, from where EP is obtained. We show that the image of a fixed cell of BHV under the inner map is the product of a cube with a number of simplices, and this number is based on the distribution of infinite edges in the corresponding tree. In particular, the cubical complex of trees where all pairwise distances are infinite folds to a single simplex under the inner map. (Received February 04, 2013)

1088-92-78 **Weifan Liu*** (weifanliu@wpi.edu), 100 Institute Road, Worcester, MA 01609. *Modeling Calcium Dynamics on Muscle Force Generation of Frog*. Preliminary report.

Currently, most models on muscle contraction do not account for the effect of calcium concentration on a microscopic level, which could significantly affect the cross-bridge attachment and thus the force. We investigate the role of calcium dynamics on muscle contraction by proposing a simplified two-compartment calcium movement model for skeletal muscle of frog. To capture the muscle contraction mechanism driven by calcium dynamics,

we coupled the system of ODEs for the Distribution Moment Model to the calcium concentration and Hodgkin-Huxley equation. Additionally, we accounted for the effect of calcium inactivation mechanism, which enabled us to produce a more authentic cytosolic calcium concentration. We modified the velocity of muscle contraction to be a variant using a damped spring mass system, as opposed to the constant velocity used in previous models. With this coupled model, we are able to investigate the role of accounting for a time dependent calcium concentration on force generation of frog. Simulation results will be presented to show how the proposed model is an accurate and efficient model that captures the muscle contraction mechanism and calcium-force relationship observed in experiments. (Received February 04, 2013)

1088-92-84 **Meghan E Reynolds*** (mereyn13@g.holycross.edu), College of the Holy Cross Box 2592, 1 College St., Worcester, MA 01610. *Population Demographics of Amphibians: Using Probabilistic Models to Estimate Abundance.*

In this project, we estimated annual abundance of a population of aquatic salamanders using probabilistic models we generated using Program MARK, a software application that allows us to model recapture data of marked individuals. Data were collected over a period of 8 years during the spring and fall seasons in a pond in Charlton, MA. Adults were captured during several trapping sessions each season and each individual was identified by natural spotting patterns on their dorsum. We constructed encounter histories for each individual over the trapping sessions, which serve as the input for our models. We then generated probabilistic models describing different types of variation in recapture probabilities and used Akaike's Information Criterion (AIC) to select the best model given the data. Program MARK uses numerical maximum likelihood techniques to compute estimates of recapture probabilities, abundance, and 95% confidence intervals. By obtaining estimates of the abundance and survival rates of newts we will be able to further investigate hypotheses regarding changes in abundances with environmental factors that would affect survival or reproduction. (Received February 04, 2013)

1088-92-101 **Leah DeCoste***, lrdeco13@g.holycross.edu. *Modeling the Limited Immune Reconstitution of HIV-1 Patients on HAART: The Damaged Niche Hypothesis.*

In this project we develop a system of ordinary differential equations to model and explore the damaged niche hypothesis for the limited immune reconstitution of HIV patients on highly active antiretroviral therapy (HAART). This hypothesis states that the HIV-induced build-up of collagen in the lymph nodes causes irreversible damage to lymph node architecture that disrupts cell signals necessary for naive CD4+ T cell survival. We have created a multi-compartment ODE model with CD4+ T cell subsets, CD8+ T cell subsets, and viral compartments for peripheral blood that is consistent with this hypothesis. We are optimizing and validating model parameters with data from an ongoing retrospective study of patient data from the HIV/AIDS Clinic at the University of Massachusetts Medical School and from published results in the literature. The UMass cohort consists of 43 patients who have undergone HAART for at least six years and have maintained undetectable viral loads. Although many patients' peripheral blood T cell counts reconstitute in this time period, for some patients this occurs more slowly or appears to plateau before counts reach normal ranges. Our goal is to elucidate the relative impact of lymph impairment, thymic inhibition, and CD8+ activation on CD4+ recovery. (Received February 04, 2013)

1088-92-109 **Daniel M. A. Duhaney*** (dmaduhaney@wpi.edu), 3 King Terrace, Spring Valley, NY 10977. *Chemotactic Signalling in A. punctulata Sperm.*

We develop a system of ODEs to model the change in calcium concentration in *A. punctulata* sperm flagella in response to chemotactic signalling. The change in calcium concentration is dependent on membrane voltage, which is in turn dependent on ion channel mechanics. We assume the ion channels can be modeled using Hodgkin-Huxley equations. We numerically solve the system of coupled non-linear ODEs and present the results for membrane voltage and calcium concentration. Experimental data, parameter estimation, and future plans to use this model to gain insight into sperm movement are discussed. (Received February 05, 2013)

1088-92-267 **Tamara Awerbuch*** (tamara@hsph.harvard.edu), Department of Global Health and Population H, MA, and **Richard Levins** and **Michaela Predescu**. *A system of Four Difference Equations for Exploring the Dynamics of Dengue Spread, and its Control.* Preliminary report.

We are expanding a previous system of three difference equations (Awerbuch-Friedlander T., Levins R. and Predescu M. Far East Journal of Applied Mathematics 37, 2: 215-228, 2009) to include the proportion of infected people that prompt the intervention. Awareness (A) is prompted by the proportion of sick people (P).

Control of Mosquitoes (M) is carried out directly by spraying, or by community intervention through the habitats (H).

$$P_{n+1} = aP_n + [1 - e^{-iM_n}](1 - P_n)$$

$$M_{n+1} = l M_n e^{-gA_n} + bH_n [1 - e^{-s M_n}]$$

$$H_{n+1} = c H_n / (1 + p A_n) + d / (1 + q A_n)$$

$$A_{n+1} = r A_n + f P_n$$

Preliminary results show that $(0, 0, 1/(1-c), 0)$ is an equilibrium point; and that there is also a positive equilibrium for $(P, M, H$ and $A)$.

Simulations show that not all the variables in the system exhibit the same dynamics. (Received February 12, 2013)

1088-92-288 **Christoph Borgers** and **Bryan Walker*** (bryan.walker@tufts.edu). *Toggling between gamma-frequency activity and suppression of cell assemblies.*

The oscillations in EEG traces are now known to be the result of the synchronous firing of large populations of neurons. Mechanisms leading to neuronal synchrony are therefore of great interest. One such mechanism is the interaction between excitatory and inhibitory neuronal populations: The excitatory cells fire, making the inhibitory ones fire, which quiets down the excitatory neurons, and when inhibition wears off, the cycle begins anew. However, this back-and-forth mechanism can work only if the inhibitory neurons are by themselves so weakly driven that they fire only in response to the excitatory neurons, not on their own. There is a threshold drive to the inhibitory neurons, above which the rhythm breaks down because the inhibitory cells overtake the excitatory ones. This threshold may have functional significance because it allows easy toggling between rhythmic activity and suppression of populations of excitatory cells, an operation that the brain must carry out in situations requiring selective attention (Börgers, Epstein, and Kopell, PNAS 2008). Here we show that the sharpness of the threshold depends on the type of bifurcation taking inhibitory neurons from rest to spiking: A Hopf bifurcation leads to a sharper threshold than a saddle-node bifurcation. (Received February 13, 2013)

93 ► *Systems theory; control*

1088-93-162 **Hongzhong Zhang*** ([hz2244@columbia.edu](mailto:h22244@columbia.edu)), 1255 Amsterdam Ave, New York, NY 10027. *Quickest detection in a system with correlated noise.*

The problem of quickest detection arises in many applications in quality control, financial surveillance, among others. In this work, we study the quickest detection of signals in a system of 2 sensors coupled by a negatively correlated noise, which receive continuous sequential observations from the environment. It is assumed that the signals are time invariant and with equal strength, but that their onset times may differ from sensor to sensor. The objective is the optimal detection of the first time at which any sensor in the system receives a signal. The problem is formulated as a stochastic optimization problem in which an extended Lorden's criterion is used as a measure of detection delay, with a constraint on the mean time to the first false alarm. The case in which the sensors employ their own cumulative sum (CUSUM) strategies is considered, and it is proved that the minimum of 2 CUSUMs is asymptotically optimal as the mean time to the first false alarm increases without bound. Implications of this asymptotic optimality result to the efficiency of the decentralized versus the centralized system of observations are further discussed. (Received February 08, 2013)

94 ► *Information and communication, circuits*

1088-94-141 **Benjamin Fine** and **Anja Moldenhauer***, Fachbereich Mathematik, Universität Hamburg, Bundesstrasse 55, 20146 Hamburg, Germany, and **Gerhard Rosenberger**. *A secret sharing scheme based on the closest vector theorem and a modification to a private key cryptosystem.*

An (n, t) secret sharing protocol, with $n, t \in \mathbb{N}$ and $t \leq n$, is a method to distribute a secret among a group of n participants in such a way that it can be recovered only if at least t of them combine their shares. We explain the steps for an (n, t) secret sharing scheme based on the closest vector theorem [first published by C.

S. Chum, B. Fine, G. Rosenberger and X. Zhang: *A proposed alternative to the shamir secret sharing scheme*. Contemporary Mathematics, 582, page 47-50, 2012]. We take a look at the security and the complexity and compare it to Shamir's secret sharing scheme. Finally we modify the (n, t) secret sharing scheme based on the closest vector theorem to a private key cryptosystem. (Received February 07, 2013)

1088-94-152 **M. Habeeb, D. Kahrobaei, C. Koupparis and V. Shpilrain***,
shpil@groups.sci.cny.cuny.edu. *Public key exchange using semidirect product of (semi)groups*.

We describe a brand new key exchange protocol based on a semidirect product of (semi)groups (more specifically, on extension of a (semi)group by automorphisms), and then focus on practical instances of this general idea. Our protocol can be based on any group, in particular on any non-commutative group. One of its special cases is the standard Diffie-Hellman protocol, which is based on a cyclic group. However, when our protocol is used with a non-commutative (semi)group, it acquires several useful features that make it compare favorably to the Diffie-Hellman protocol. Here we also suggest a particular non-commutative semigroup (of matrices) as the platform and show that security of the relevant protocol is based on a quite different assumption compared to that of the standard Diffie-Hellman protocol. (Received February 08, 2013)

1088-94-222 **Rainer Steinwandt*** (rsteinwa@fau.edu), FAU, Department of Mathematical Sciences,
777 Glades Road, Boca Raton, FL 33431. *Implementing Binary Elliptic Curve Addition as Quantum Circuit*.

Cyclic subgroups of elliptic curves are one of the most prominent mathematical platforms in cryptography. To solve the discrete logarithm problem in such a group with Shor's algorithm, the group law needs to be realized as a quantum circuit. While the asymptotic complexity of such a computation is understood, not much work on optimizations at the circuit level is available.

For the case of binary elliptic curves, this talk discusses the implementation of point addition as a quantum circuit. A main focus is on how the choice of a particular field or curve representation affects the (gate) complexity of the resulting circuit.

The presentation is based on joint work with Brittanney Amento and Martin Rötteler. (Received February 11, 2013)

97 ► *Mathematics education*

1088-97-22 **Jeffrey J Beyerl*** (jeff.beyerl@furman.edu). *Mathematics and Wikiversity*. Preliminary report.

Wikiversity is a sister project of Wikipedia which offers user-developed courses. These courses are meant to be stand-alone resources on the topic. I designed a trial program in an introductory mathematics course to have the students write a Wikiversity for the course they're enrolled in. In this talk I will present some of the history of Wikiversity in regards to mathematics, and the successes and failures of this trial program. (Received December 18, 2012)

BOULDER, CO, April 13–14, 2013

Abstracts of the 1089th Meeting.

00 ► *General*

1089-00-346 **Denis Albertovich Silantyev*** (dsilant@unm.edu), **Harvey Rose** and **Pavel Lushnikov**. *Vlasov-Poisson model and its reduction for laser-plasma 2D simulation*.

One of the common ways to model collisionless plasma-laser interaction is to consider Vlasov-Poisson system. Since modeling of plasma dynamics by solving Vlasov equation directly in 2 (and especially 3) spatial dimensions is computationally very challenging task we consider the reduced model that we call Vlasov Multi-Dimensional model (VMD).

VMD model is specifically designed to take advantage of solution properties in regimes when plasma waves are confined to a narrow cone. Linear stability analysis of VMD model is done in order to understand some limitations that this reduction imposes on the system. Simulations of 2D plasma-laser interaction are performed with VMD model and the results are compared to full 2D Vlasov simulations performed using PIC codes and finite volume methods. (Received February 18, 2013)

03 ► *Mathematical logic and foundations*

1089-03-60 **Jaykov Foukzon*** (jaykovfoukzon@list.ru), , Israel. *An possible generalization of the Löb's theorem*. Preliminary report.

An possible generalization of the Löb's theorem is considered. <http://arxiv.org/abs/1301.5340> (Received January 26, 2013)

1089-03-178 **David Chodounsky*** (david.chodounsky@matfyz.cz). *Hausdorff Gaps and Towers in $\mathcal{P}(\omega)/fin$* .

The classical result of Kunen states that a gap $(L_\alpha, R_\alpha)_{\alpha \in \omega_1}$ in $\mathcal{P}(\omega)/fin$ is indestructible iff $(L_\alpha \cap R_\beta) \cup (L_\beta \cap R_\alpha) \neq \emptyset$ for each $\alpha < \beta \in \omega_1$. (This has to hold for some cofinal subgap.) The classical construction of Hausdorff produces a gap such that $\{\alpha < \beta: L_\alpha \cap R_\beta \subset n\}$ is finite for each $\beta \in \omega_1$ and $n \in \omega$. We show that this two indestructibility conditions are consistently different.

We also study combinatorics of towers - well ordered \subset^* -chains in $\mathcal{P}(\omega)/fin$. We call the tower $(T_\alpha)_{\alpha \in \omega_1}$ Suslin if each cofinal subtower contains two elements in inclusion, and Hausdorff if $\{\alpha < \beta: T_\alpha \setminus T_\beta \subset n\}$ is finite for each $\beta \in \omega_1$ and $n \in \omega$. We show that assuming MA all towers are Hausdorff, Hausdorff towers generate ideals of maximal Tukey order among posets of size ω_1 and there can be a tower, which is not equivalent to any Hausdorff nor Suslin tower.

This is joint work with P. Borodulin-Nadzieja. (Received February 13, 2013)

1089-03-203 **Paul B. Larson*** (larsonpb@miamioh.edu), Department of Mathematics, Miami University, Oxford, OH 45056. *Scott Processes*. Preliminary report.

We present a proof of an unpublished theorem of Harrington showing that a counterexample to Vaught's Conjecture has models of arbitrarily large Scott rank below ω_2 , and discuss some possible extensions. (Received February 15, 2013)

1089-03-257 **Kai Maeda*** (kaimaeda@gwu.edu). *Application of computability theory to the study of quandles*. Preliminary report.

Quandles are important examples of magmas, which come from knot theory where they are used to produce invariants of links. Quandles were introduced and first studied by Joyce and Matveev. Turing degrees were introduced in computability theory by Post to measure relative computability-theoretic complexity of mathematical objects. There are uncountably many Turing degrees and they form an upper semi-lattice. We apply the methods of computability theory to investigate the complexity of countable quandles. We show that for various quandles from several important natural subclasses, the sets of Turing degrees of all isomorphic quandles form certain upper cones in the Turing degrees.

(Preliminary report.) (Received February 17, 2013)

1089-03-289 **Jean A. Larson*** (jal@uf1.edu). *Laver and his mathematics*. Preliminary report. Richard Laver had pivotal results in different areas of mathematics. I will review some of his interests and some of the influences on his mathematics. Then I will highlight some of his accomplishments and survey open problems that interested him. (Received February 18, 2013)

1089-03-327 **Dana Bartosova*** (dana.bartosova@utoronto.ca), 40 St. George Street, Toronto, Ontario M5S 2E4, Canada. *Filter dynamical systems*. We give an internal characterization of Boolean algebras of clopen subsets of universal minimal flows for groups automorphisms of first-order structures. We show how this approach applies to arbitrary topological groups, generalizing algebra in the Čech-Stone compactification of discrete groups to the Samuel compactification of topological groups. (Received February 18, 2013)

1089-03-352 **David Milovich*** (david.milovich@tamiu.edu). *A recipe for homogeneous compacta*. Preliminary report. We answer a question of Heindorf and Shapiro: there is a non-free rc-filtered boolean algebra with homogeneous Stone space. Our minimal specific example is, in topological terms, the clopen algebra of an openly generated homogeneous 0-dimensional compactum X with a continuous surjection onto the Vietoris hyperspace of 2^{\aleph_2} .

Abstracting from our proof, we introduce sufficient hypotheses—we call them narrow cocompleteness, mixing, and lifting—for a class \mathcal{B} of boolean algebras (possibly with extra structure) and associated classes \mathcal{E} and \mathcal{I} of embeddings and involutions to be such that every $A \in \mathcal{B}$ has an \mathcal{E} -embedding into some $B \in \mathcal{B}$ whose Stone space is homogeneous, with homogeneity witnessed by \mathcal{I} -involutions of B .

For constructing X as above, the relevant \mathcal{E} consists of what we call multicommutative embeddings between directed systems of finite boolean algebras. We will also discuss related results and questions for when \mathcal{E} consists of projective embeddings, rc embeddings, or arbitrary embeddings. (Received February 19, 2013)

1089-03-360 **Andreas R. Blass*** (ablass@umich.edu), Mathematics Dept., Univ. of Michigan, 530 Church Street, Ann Arbor, MI 48109-1043. *Fragile Ultrafilters*. Preliminary report. I shall discuss various aspects of the question of preservation (or non-preservation) of ultrafilters on the natural numbers in forcing (and other) extensions of models of set theory. (Received February 19, 2013)

1089-03-397 **Timothy O Trujillo*** (timothy.trujillo@du.edu). *Selective and Ramsey for \mathcal{R}_1 Ultrafilters and Their Dedekind Cuts*. Let \mathcal{V} be an ultrafilter on ω . To each function $p : \omega \rightarrow \omega$ and each ultrafilter \mathcal{U} mapped to \mathcal{V} by p , we associate a Dedekind cut in the ultrapower $\omega^\omega/\mathcal{V}$. Assuming CH, Andreas Blass has characterized the cuts obtainable in this manner when various restrictions are imposed on \mathcal{U} and p . In particular, the cuts obtainable when \mathcal{U} is a weakly-Ramsey ultrafilter have been characterized.

In this talk, we describe the topological Ramsey space \mathcal{R}_1 and then define the notions of selective for \mathcal{R}_1 ultrafilter and Ramsey for \mathcal{R}_1 ultrafilter. It is known that Ramsey for \mathcal{R}_1 ultrafilters are also weakly-Ramsey ultrafilters and any weakly-Ramsey ultrafilter generated by a subset of \mathcal{R}_1 is also a selective for \mathcal{R}_1 ultrafilter. The space \mathcal{R}_1 is equipped with a special function π whose restriction is neither constant nor one-to-one on any element of \mathcal{R}_1 . We characterize the cuts obtainable when \mathcal{U} is taken to be a Ramsey for \mathcal{R}_1 ultrafilter or a Selective for \mathcal{R}_1 ultrafilter and p is taken to be π . (Received February 19, 2013)

05 ► *Combinatorics*

1089-05-22 **Craig M Timmons*** (ctimmons@ucsd.edu). *k-fold Sidon sets*. Let G be an abelian group. A set $A \subset G$ is a *k-fold Sidon set* if A has only trivial solutions to equations of the form

$$c_1x_2 + c_2x_2 + c_3x_3 + c_4x_4 = 0$$

where $|c_i| \leq k$ and $c_1 + c_2 + c_3 + c_4 = 0$. Such sets were introduced by Lazebnik and Verstraëte in 2003 while investigating hypergraphs of girth 5. In this talk we will present some upper and lower bounds on the maximum size of a k -fold Sidon set contained in the interval $\{1, 2, \dots, N\}$ and in the group \mathbb{Z}_N . We will present an application of such sets to the following problem in extremal graph theory: determine the maximum number of edges in an n -vertex graph such that every edge is in a unique 4-cycle. (Received December 17, 2012)

1089-05-32 **Ralph J Faudree*** (rfaudree@memphis.edu), 235 Winfield Dunn Building, University of Memphis, Memphis, TN, Memphis, TN 38152. *Saturation Numbers.*

A graph G is an H -saturated graph if G does not contain H as a subgraph, but $G \cup \{e\}$ contains a copy of H for any edge e not in G . The *saturation number* of H , denoted by $sat(H, n)$, is the minimum number of edges in an H -saturated graph G of order n . A survey of some of the classical results on saturation numbers will be presented, also with a comparison of the saturation number $sat(n, H)$ with the Turán extremal number $ex(n, H)$. Also, the concept of *weak saturation*, denoted by $wsat(n, H)$, will be introduced and comparisons of the extremal numbers $ex(n, H)$, $sat(n, H)$ and $wsat(n, H)$ will be made. However, the focus will be on some recent results on weak saturation numbers, and some open problems. (Received January 15, 2013)

1089-05-34 **Cristian Lenart, Satoshi Naito, Daisuke Sagaki, Anne Schilling*** (anne@math.ucdavis.edu) and **Mark Shimozono.** *A uniform combinatorial model for Kirillov-Reshetikhin crystals and specialized Macdonald polynomials.* Preliminary report.

Our goal is to prove that $P_\lambda(q) = X_\lambda(q)$, where $P_\lambda(q)$ is the Macdonald polynomial $P_\lambda(q, t)$ specialized at $t = 0$ and $X_\lambda(q)$ is the graded character of a simple Lie algebra coming from tensor products of Kirillov-Reshetikhin (KR) modules. In pursuit of this goal, we present a new explicit formula for the X polynomials, by characterizing the previously inexplicit formula using projected Lakshmibai-Seshadri (LS) paths, in terms of the parabolic quantum Bruhat graph (a combinatorial device coming from quantum cohomology of homogeneous spaces). This is achieved by establishing a lifting of the projected LS paths to the level-0 weight poset, which was first introduced by Littelmann. We also show a generalization of results by Deodhar which involves the compatibility of the quantum Bruhat graph with the cosets for every parabolic subgroup of the Weyl group. This should be the key structure to establish $P = X$. (Received January 15, 2013)

1089-05-35 **Mike Develin, Matthew Macauley and Victor Reiner*** (reiner@math.umn.edu), School of Mathematics, Univ. of Minnesota, 206 Church St. SE, Minneapolis, MN 55455. *Toric partial orders.*

We define toric partial orders, corresponding to regions of graphic toric hyperplane arrangements, just as ordinary partial orders correspond to regions of graphic hyperplane arrangements. Combinatorially, toric posets correspond to finite posets under the equivalence relation generated by converting minimal elements into maximal elements, or sources into sinks.

We derive toric analogues for several features of ordinary partial orders, such as chains, antichains, transitivity, Hasse diagrams, linear extensions, and total orders. (Received January 15, 2013)

1089-05-37 **Jonathan Comes**, Dept. of Mathematics, University of Oregon, Eugene, OR 97403, and **Jonathan Kujawa***, Dept. of Mathematics, University of Oklahoma, Norman, OK 73019. *Ideals and traces in Deligne's category $Rep(S_t)$.*

In 2007 Deligne combinatorially defined a category $Rep(S_t)$ for any complex number t . These categories interpolate between the representations of the symmetric groups in that when t is a positive integer you can recover the complex representations of the symmetric group S_t from his category. We'll present from scratch Deligne's delightful construction and present some new results about these categories. This work is joint with J. Comes. (Received January 16, 2013)

1089-05-65 **Andrew D King*** (adk7@sfu.ca), Department of Mathematics, Simon Fraser University, 8888 University Drive, Burnaby, BC V5A 1S6, Canada. *Getting to the point of Reed's Conjecture: How local can you go?*

Reed's omega, Delta, chi conjecture proposes a bound on the chromatic number based on the two global invariants omega and Delta. It may be very roughly stated, "For a graph to have high chromatic number, it must contain a large clique and a vertex of high degree."

But omega and Delta may be realized in completely different parts of the graph. It therefore seems natural to strengthen this conjecture, and propose that if a graph has high chromatic number, then a large clique and a vertex of high degree must occur in the same local area of the graph. In this talk I will discuss what strengthenings of this type we might reasonably make, and present evidence and counterexamples that narrow the threshold.

This is joint work with Katherine Edwards. (Received January 28, 2013)

1089-05-79 **Thomas Lam*** (tflam@umich.edu) and **Pavlo Pylyavskyy.** *Electrical networks and Lie theory.*

I will consider electrical networks consisting only of resistors. Two networks are considered electrically equivalent if they have the same electrical properties: for example, two resistors in series, or in parallel can be replaced by

a single one. We investigate the question of whether electrical equivalence relations can be thought of as the relations in a (Lie) group. (Received February 01, 2013)

1089-05-86 **Alexandr Kostochka***, kostochk@math.uiuc.edu, Urbana, IL 61801, and **Matthew Yancey**. *Extremal graphs for Gallai's Conjecture on the minimum size of k -critical n -vertex graphs*. Preliminary report.

A graph G is k -critical if the chromatic number of G is k , but the chromatic number of every its proper subgraph is less than k . In particular, every graph with chromatic number k contains a k -critical subgraph. Dirac in 1957 posed the problem of finding the minimum number of edges, $f_k(n)$, in an n -vertex k -critical graph. It is well known that $f_3(n) = n$ for all odd $n \geq 3$, but for $k \geq 4$, the values of $f_k(n)$ were known only for small n . Gallai in 1963 conjectured that $f_k(n) = \frac{(k+1)(k-2)n-k(k-3)}{2(k-1)}$ for each $k \geq 4$ and $n \equiv 1 \pmod{k-1}$, $n \geq k$. Very recently, the authors proved this conjecture and determined the values of $f_4(n)$ for every $n \geq 6$. The aim of the talk is to prove a Brooks-type result: We describe all k -critical n -vertex graphs with exactly $\frac{(k+1)(k-2)n-k(k-3)}{2(k-1)}$ edges. As a corollary we determine the values of $f_5(n)$ for every $n \geq 7$. (Received February 03, 2013)

1089-05-88 **Dylan Rupel*** (d.rupel@neu.edu), Department of Mathematics, Northeastern University, Boston, MA 02115. *Rank 2 Non-commutative Laurent Phenomenon and Positivity*.

Rank 2 cluster algebras are defined recursively using a pair of binomial exchange relations. In this talk I will generalize this construction in two directions. I will work in the fully non-commutative setting and consider polynomial generalizations of the exchange relations. My main result will be a combinatorial description of the resulting "cluster variables" which establishes a Laurent phenomenon and positivity for certain polynomial exchanges. (Received February 03, 2013)

1089-05-89 **Nantel Bergeron***, York University, Dept. of Mathematics and Stat., Toronto, Ontario M3J1P3, Canada, and **C. Berg, F. Saliola, L. Serrano** and **M. Zabrocki**. *Immaculate basis and the non-commutative littlewood richardson rule*.

We have defined a new basis for $NSym$, the non-commutative symmetric functions. We called it the immaculate basis and denote it I_α indexed by compositions α . This basis has the property that the forgetful map χ from $NSym$ to symmetric function gives $\chi(I_\alpha) = s_\alpha$ where $s_\alpha = \det(h_{\alpha_i - i + j})$ is the Schur function defined by the Jacobi-Trudi determinant. In particular the s_α make sense even for a composition α .

we give versions of the right Pieri rule and non-commutative Littlewood-Richardson rules in this context. The non-commutative Littlewood-Richardson coefficient $C_{\alpha,\lambda}^\beta$ are shown to be all positive (for a partition λ) and satisfies a fascinating new relation.

We also construct indecomposable modules for the 0-Hecke algebra whose characteristics are the dual immaculate basis of the quasi-symmetric functions. (Received February 03, 2013)

1089-05-103 **H Kierstead, A Kostochka** and **E Yeager***, 1409 W Green St, Urbana, IL 61801. *A Refinement of the Corrádi-Hajnal Theorem*.

In 1963, Corrádi and Hajnal proved the following theorem:

If G is a graph with at least $3k$ vertices and minimum degree at least $2k$, then G contains k vertex-disjoint cycles. We present a refinement:

Let k be at least 4. If G is a graph with at least $3k + 1$ vertices, minimum degree-sum at least $4k - 3$, and independence number at most $|V(G)| - 2k$, then G contains k vertex-disjoint cycles. (Received February 14, 2013)

1089-05-111 **David J Galvin*** (dgalvin1@nd.edu), Department of Mathematics, University of Notre Dame, Notre Dame, IN. *Some extremal questions for independent sets*.

The question of maximizing the count of independent sets in the family of regular graphs (with fixed order and degree) has received considerable attention since it was first raised by Granville in the late 80's.

More recently, the question has been asked: what happens when the regularity condition is relaxed? A particular direction that has led to some nice results and questions is to consider graphs of fixed order satisfying a minimum degree lower bound.

I'll review some results (including joint work with John Engbers) and mention some open problems. (Received February 07, 2013)

1089-05-117 **Jeno Lehel***, University of Memphis. *Hypergraph irregularity*.

A hypergraph is irregular if it has no repeated degrees. With Gyárfás, Jacobson, Kinch and Schelp, we showed in 1992 that there exist irregular r -uniform hypergraphs of order n if and only if $r \geq 3$ and $n \geq r + 3$. We also proved that almost every random r -uniform hypergraph has no repeated degrees, for every $r \geq 6$, when the edges

emerge independently with probability $p = 1/2$. Here we assume that p is a function of n and asymptotically determine the probability that a random r -uniform hypergraph is irregular, for every fixed $r \geq 3$.

We obtain that in a random r -uniform hypergraph asymptotically almost surely there exist repeating degrees for $r = 3$ and 4. In contrast, asymptotically almost surely there is no degree repetition for $r \geq 6$ and any constant p , $0 < p < 1$. In this regard the value $r = 5$ behaves like a “threshold” with respect to the rank r for the property that an r -uniform hypergraph is asymptotically almost surely irregular or not. /Joint work with P. Balister, B. Bollobás, and M. Morayne./ (Received February 08, 2013)

1089-05-122 **Andrew Berget** and **Alex Fink*** (arfink@ncsu.edu). *Matroids and stabilization of K -polynomials.*

A full-rank $r \times n$ matrix, read columnwise, gives a configuration of n points spanning \mathbb{P}^{r-1} . The matrices yielding the same configuration, up to automorphisms of \mathbb{P}^{r-1} , can be considered to form a torus orbit in a Grassmannian, or a GL_r cross torus orbit in the affine space of matrices.

Speyer showed that the equivariant K-class of closures of the former orbits depends only on the matroid of the point configuration. In joint work with Andrew Berget, we have lifted this to orbit closures of the latter kind. I will present this result with a focus on the key idea involved in the lifting, a generalization of a stabilization technique for cohomology used by Fehér and Rimányi. (Received February 08, 2013)

1089-05-132 **Chris Anderson**, **Marion Scheepers**, **Marlena Warner** and **Helen Wauck*** (hwauck@gustavus.edu), Gustavus Adolphus College, 800 W. College Ave., Saint Peter, MN 56082. *Mathematical Representations of Ciliate Genome Decryption.* Preliminary report.

Ciliates are unique unicellular organisms that each contain a scrambled version of their own DNA which must be unscrambled for proper gene expression. Ciliates have developed three DNA operations for this purpose: reversals, block interchanges, and excisions. Using integer permutations to represent scrambled DNA segments, we can develop a simple mathematical model for each of these operations. This model can be enhanced by visualizing permutations of integers as directed graphs. Studying ciliate DNA operations using these numeric and visual representations has yielded a number of curious insights into the mechanics of ciliate genome unscrambling. In this talk we present some of our mathematical findings. (Received February 16, 2013)

1089-05-133 **Ibrahim A Saleh*** (ibrahim.saleh@uwc.edu), 518 South 7th Avenue, Wausau, WI 54401. *A cluster structure on some hyperbolic categories.* Preliminary report.

In this talk, I will introduce a class of categories that carry a cluster structure. Each of these categories is related to a category of representations of some hyperbolic algebra. The cluster structures on these categories are inherited from the non-commutative cluster structures on the underground algebras. Example of the related categories is the category of representations of Weyl Algebra. (Received February 10, 2013)

1089-05-156 **Chris Anderson*** (canderson@clark.edu), 0615 SW Palatine Hill Road, MSC 237, Portland, OR 97219, and **Marion Scheepers**, **Marlena Warner** and **Helen Wauck**. *Biological Implications of the Mathematical Properties of Ciliate Genome Decryption.* Preliminary report.

Ciliates are a fascinating family of protozoa which store their genetic information in an encrypted micronucleus - before any ciliate gene can be expressed, it must be unscrambled based on a set of genetic “pointers” and copied into a decrypted macronucleus. Representing the scrambled micronuclear DNA as integer permutations of the canonical gene sequences reveals that ciliate molecular machinery is capable of inverting certain permutations. Though we cannot yet precisely describe the set of ciliate-invertible permutations, we have observed optimal patterns for the decryption mechanism, leading to specific hypotheses about the permutations possible in real-world ciliate DNA. In this talk we present some of our findings. (Received February 12, 2013)

1089-05-161 **Carolina Benedetti*** (caro.benedetti@gmail.com), 1417-1369 Bloor st west, Toronto, ON M6P4J4, Canada, and **Nantel Bergeron**. *Schubert polynomials and k -Schur functions.*

In this talk we study operators associated to the graph on dual k -Schur functions given by the affine grassmannian order. These operators are analog to the ones given for the r -Bruhat order by Bergeron-Sottile. This allows us to understand combinatorially the multiplication of a Schubert polynomial by a Schur function from the multiplication in the space of dual k -Schur functions. (Joint work with Nantel Bergeron). (Received February 12, 2013)

1089-05-173 **Jihui Huang*** (huang.684@osu.edu), 231 W 18th Ave, Columbus, OH 43210.
Classification of soliton graphs for KP equation.

The Kadomtsev-Peviasvili (KP) equation describes 2-dimensional wave patterns observed in shallow water. The solutions called KP solitons are parametrized by totally non-negative Grassmann variety. The soliton graphs are the patterns generated by the KP solitons. For $\text{Gr}(1,n)$ and $\text{Gr}(2,n)$ cases, the soliton graphs can be constructed from the triangulations of n -gon. However, in general, even for $\text{Gr}(3,n)$ case, the soliton graphs can be very complicated, and they have not been classified. We intend to classify the soliton graphs for general case of $\text{Gr}(k,n)$ using the symmetries of the KP equation, the KP hierarchy. Then the soliton graphs are considered as the dual graphs to subdivisions of zonotopes generated by the multiple times of the symmetry parameters in the KP hierarchy. We show that topological representation of zonotopal tilings leads to a classification of the soliton graphs. In this talk, we illustrate the classification using the soliton graphs for $n=5$ and $n=6$ cases. (Received February 13, 2013)

1089-05-186 **Ronald J. Gould*** (rg@mathcs.emory.edu), Dept. of Math and CS, Emory University, Atlanta, GA 30322. *Forbidden Subgraphs and Hamiltonian Connected Graphs.*

We trace the development of results on forbidden pairs of graphs implying 3-connected graphs are hamiltonian connected. We will also show examples helping to trim the possible candidate pairs. Finally, we show that any 3-connected, claw and P_9 free graph is hamiltonian connected. (Received February 14, 2013)

1089-05-191 **Michael Ferrara, Michael Jacobson, Florian Pfender and Paul S. Wenger*** (pswsma@rit.edu). *Saturated Subgraphs of Multipartite Graphs.*

Given graphs G and H , a subgraph J of G is H -saturated if H is not a subgraph of J , but the addition of any new edge from G to J completes a copy of H . In this talk we present results on the minimum size of K_t -saturated subgraphs of complete balanced multipartite graphs. These results provide a contrast to recent results about the maximum edge density of K_t -free subgraphs of complete multipartite graphs. (Received February 14, 2013)

1089-05-202 **Amin Bahmanian*** (mbahmani@uottawa.ca), 585 King Edward Ave., Department of Math and Stat, University of Ottawa, Ottawa, Ontario K1N 6N5, Canada. *2-edge-connected fair detachments of (≤ 3) -graphs.*

A detachment of a (hyper)graph is formed by splitting each vertex into one or more subvertices, and sharing the incident edges arbitrarily among the subvertices. Given a hypergraph \mathcal{F} whose edges are of size at most 3, we provide necessary and sufficient conditions for the existence of a fair detachment \mathcal{G} of \mathcal{F} in which each color class is 2-edge-connected, which generalizes Nash-Williams' Theorem. Then we find 2-edge-connected factorizations for K_n^3 (the complete 3-uniform hypergraph on n vertices) which generalizes Baranyai's Theorem restricted to 3-uniform hypergraphs. If time permits, we discuss the minimum number n of new vertices we need to add to an edge-coloring C of K_m^3 so that C can be extended to an edge-coloring of K_{m+n}^3 in which each color class is a 2-edge-connected r -factor. (Received February 15, 2013)

1089-05-204 **Glenn H Hurlbert*** (hurlbert@asu.edu), Arizona State University. *EKR on Graphs and Lattices.*

The classic theorem of Erdős, Ko, and Rado has generated a lot of activity in recent years. One new idea explores the structure of intersecting families of maximum size under the restriction that certain pairs of elements cannot be in the same set. This corresponds to investigating the largest intersecting family of independent sets of a graph. If some such family forms a star – some element is in every set – the graph is said to have the EKR property. A second consideration studies intersection of other objects, such as permutations and partitions (defined by sharing the same coordinate or block, respectively), and asking the usual Erdős-Ko-Rado and Hilton-Milner type questions. A third notion defines the intersection of elements of a lattice by to the rank of their meet. Here, a lattice is said to be EKR if a largest intersecting family of elements forms a star; that is, it is the upset of an atom. We discuss current advances in these areas, including joint work with Bekmetjev, Brightwell, Czygrinow, Fishel, Kamat, and Meagher. (Received February 15, 2013)

1089-05-209 **Csaba Biro, Adam Jobson and Andre Kezdy*** (kezdy@louisville.edu), Department of Mathematics, Natural Sciences Building Room 328, University of Louisville, Louisville, KY 40292. *All minor-minimal apex obstructions that have connectivity two.* Preliminary report.

A graph is an apex graph if it contains a vertex whose deletion produces a planar graph. The family of apex graphs is a fundamental minor-closed family, yet the finite list of minor-minimal apex obstructions remains unknown. We have recently determined all minor-minimal apex obstructions that have connectivity two (there are well over 100). In this talk I will present these graphs, sketch the main ideas in our proof to show the list is

complete, and comment on our progress finding all minor-minimal apex obstructions. (Received February 15, 2013)

1089-05-220 **Edward Richmond*** (erichmond@math.ubc.ca) and **William Slofstra**. *Coxeter groups and Poincaré polynomials.*

Let W be a Coxeter group. For any $w \in W$, let P_w denote its Poincaré polynomial (i.e. the generating function of the principle order ideal of w with respect to length). If W is the Weyl group of some Kac-Moody group G , then P_w is the usual Poincaré polynomial of the corresponding Schubert variety X_w . In this talk, I will discuss joint work with W. Slofstra on detecting when the sequence of coefficients of a Poincaré polynomial are the same read forwards and backwards (i.e. palindromic). The polynomial P_w satisfies this property precisely when the Schubert variety X_w is rationally smooth. It turns out that this property is easy to detect when the Coxeter group W avoids certain rank 3 parabolic subgroups (triangle groups). One consequence is that, for many Coxeter groups, the number of elements with palindromic Poincaré polynomials is finite. Explicit enumerations and descriptions of these elements are given in special cases. (Received February 15, 2013)

1089-05-221 **Elizabeth Beazley*** (ebeazley@haverford.edu), Department of Mathematics, 370 Lancaster Avenue, Haverford, PA 19041, and **Margaret Nichols**, **Min Hae Park**, **Xiaolin Shi** and **Alexander Youcis**. *Bijjective Projections on Parabolic Quotients of Affine Weyl Groups.*

Affine Weyl groups and their parabolic quotients are used extensively as indexing sets for objects in representation theory, algebraic geometry, and number theory. Moreover, we can conveniently realize the elements of certain quotients via intuitive geometric and combinatorial models such as abaci, alcoves, coroot lattice points, and core partitions. Berg, Jones, and Vazirani have described a bijection between n -cores with first part equal to k and $(n-1)$ -cores with first part less than or equal to k . In this talk we will discuss how to generalize this bijection of Berg, Jones, and Vazirani to parabolic quotients of affine Weyl groups in other classical Lie types. We have developed not only combinatorial techniques to describe this map, but also a geometric method utilizing the properties of the alcove model coming from the root system associated to the affine Weyl group. (Received February 15, 2013)

1089-05-259 **Marcelo Aguiar*** (maguiar@math.tamu.edu), **Swapneel Mahajan** and **Jacob White**. *Rings and near rings in algebraic combinatorics.*

After motivating examples of a combinatorial nature, we discuss the notion of (near) ring in a 2-monoidal category. We explain in what sense the space of symmetric functions behaves just like the ring of integers. The faces of the braid arrangement give rise to a near ring intimately related to noncommutative symmetric functions.

This talk draws from joint work with Swapneel Mahajan and Jacob White. (Received February 17, 2013)

1089-05-265 **Michael Young*** (myoung@iastate.edu). *Anti-Ramsey Multiplicities of Graphs and Arithmetic Progressions.* Preliminary report.

A graph is rainbow if each edge of the graph is distinctly colored. In this talk we discuss results to the following question: Given a graph G and r colors, what is the maximum number of rainbow copies of G in an r -edge colored K_n ? A k -term arithmetic progression, $a, a+d, \dots, a+(k-1)d$, is rainbow if each term is assigned a distinct color. We discuss results of maximizing the number of rainbow arithmetic progressions in r -colorings of $[n]$ and Z_n . (Received February 17, 2013)

1089-05-269 **Georgia Benkart*** (benkart@math.wisc.edu), Department of Mathematics, University of Wisconsin-Madison, Madison, WI 53706, and **Tom Halverson** (halverson@macalester.edu), Department of Mathematics, Macalester College, St. Paul, MN 55105. *McKay Centralizer Algebras II.*

The finite subgroups of SU_2 and the affine simply-laced Dynkin diagrams are in bijection by the celebrated McKay correspondence. This talk will focus on combinatorial results coming from the centralizer algebra $Z_k(\mathbb{G}) = \text{End}_{\mathbb{G}}(\mathbb{V}^{\otimes k})$ of the action of \mathbb{G} on the k -fold tensor product of its defining 2-dimensional representation \mathbb{V} and its connections with partitions, diagram walks, and more. (Received February 17, 2013)

1089-05-283 **Jim Haglund***, 209 S. 33rd St., Math. Dept., UPenn, Philadelphia, PA 19104-6395, and **Adriano Garsia**. *Recent Results Involving Tesler Matrices and Diagonal Harmonics*. Preliminary report.

Tesler matrices have previously been shown by the speaker to parameterize a combinatorial formula for the Hilbert series of the space of Diagonal Harmonics. Further aspects of this connection were developed by Armstrong, Garsia, Rhoades, Sagan, and the speaker. In this talk we discuss some more recent developments, including a formula of Garsia and the speaker which gives a Tesler matrix expression for the character of Diagonal Harmonics. (Received February 18, 2013)

1089-05-284 **Ross Willard*** (rdwillar@uwaterloo.ca), Pure Mathematics Department, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada. *Bipartite graphs and their idempotent polymorphisms*. Preliminary report.

Feder and Vardi reduced the general Constraint Satisfaction Problem Dichotomy Conjecture to the special case of bipartite graphs with constants. According to the Algebraic CSP Dichotomy Conjecture, the complexity of the CSP for a bipartite graph with constants should be completely determined by the identities (i.e., “Maltsev conditions”) satisfied by the idempotent polymorphisms of the bipartite graph. We prove two results.

- (1) Call a digraph **strongly bipartite** if each vertex is either a source or a sink, but not both. Call a set with two equivalence relations a **2-equivalence structure** if the relations meet to the diagonal. We describe more-or-less obvious translations between finite bipartite graphs, finite strongly bipartite digraphs, and finite complement structures, and show that these translations preserve all “interesting” idempotent Maltsev conditions.
- (2) Using (1), we show that if a finite bipartite graph (or strongly bipartite digraph, or complement structure) has polymorphisms satisfying the Hagemann-Mitschke identities characterizing congruence 5-permutability, then it has a near-unanimity polymorphism.

(Received February 18, 2013)

1089-05-294 **Lauren Keough***, s-lkeough1@math.unl.edu, and **A.J. Radcliffe**. *Graphs with the Fewest Matchings*. Preliminary report.

We are interested in the problem of which graphs on n vertices and e edges have the minimum number of matchings. A graph with the fewest matchings can be found among the threshold graphs. In the bipartite graph case we find that the lex bipartite graph attains the minimum number of matchings of every size. We use this to show that either the lex or the colex graph attains the minimum number of matchings in the general graph case. (Received February 18, 2013)

1089-05-299 **Ian T Le*** (iantuanle@gmail.com), Department of Mathematics, 2033 Sheridan Rd., Evanston, IL 60208-2730. *Positive Configurations in Affine Buildings*.

I will define positive configurations of points inside the affine building for SL_n , which can be viewed as a higher dimensional generalization of planar trees. They arise as the tropical points of higher Teichmüller space, and the construction involves the cluster algebra structure on higher Teichmüller space.

While general configurations of points in the affine building are rather complicated, positive configurations can be written explicitly, and have a simple parameterization. I will highlight some of their interesting features, like their combinatorial types and duality pairings between configurations. (Received February 18, 2013)

1089-05-308 **Radmila Sazdanovic*** (radmilas@math.upenn.edu), 209 south 33rd street, department of mathematics, Philadelphia, PA 19104, and **Vladimir Baranovsky**. *Categorifications of the chromatic polynomial*.

We will discuss the proof of the conjecture due to M. Khovanov relating the algebraic and topological categorification of the chromatic polynomial. We show that there exists a spectral sequence relating the chromatic graph homology defined by L. Helme-Guizon and Y. Rong and the homology of a graph configuration space introduced by M. Eastwood, S. Huggett. (Received February 18, 2013)

1089-05-343 **Oleg V. Borodin** (brdnoleg@math.nsc.ru), **Alexandr V. Kostochka** (kostochk@math.uiuc.edu), **Bernard Lidický*** (lidicky@illinois.edu) and **Matthew Yancey** (yancey1@illinois.edu). *Short proofs of coloring theorems on planar graphs*.

A recent lower bound on the number of edges in a k -critical n -vertex graph by Kostochka and Yancey yields a half-page proof of the celebrated Grötzsch Theorem that every planar triangle-free graph is 3-colorable. In this talk we use the same bound to give short proofs of other known theorems on 3-coloring of planar graphs, among whose is the Grünbaum-Aksenov Theorem that every planar with at most three triangles is 3-colorable. We also

prove the new result that every graph obtained from a triangle-free planar graph by adding a vertex of degree at most four is 3-colorable. (Received February 18, 2013)

1089-05-349 **Louis DeBiasio** and **Theodore Molla*** (tmolla@asu.edu). *The semi-degree threshold for anti-directed Hamilton cycles.*

Let D be a directed graph on n vertices and let $\delta^0(D) := \min_{v \in V(D)} \{\min\{d^+(v), d^-(v)\}\}$ be the minimum semi-degree of D . Here $d^+(v)$ and $d^-(v)$ are the outdegree and indegree of the vertex v respectively. In 1960 Ghouila-Houri proved an extension of Dirac's Theorem which has the following corollary: If $\delta^0(D) \geq \frac{n}{2}$ then D has a directed Hamilton cycle. We will show that for sufficiently large even n , if $\delta^0(D) \geq \frac{n}{2} + 1$ then D contains an anti-directed Hamilton cycle, i.e. a cycle on n vertices in which no pair of consecutive arcs form a directed path. Clearly n must be even for such a cycle to exist and, as Cai demonstrated in 1983, the semi-degree condition is tight. The proof uses the probabilistic absorbing technique in a manner similar to Levitt, Sárközy and Szemerédi.

This is joint work with Louis DeBiasio. (Received February 19, 2013)

1089-05-357 **Christian Stump*** (stump@math.uni-hannover.de). *Revisiting the combinatorics of generalized cluster complexes and generalized associahedra in finite types.*

I will present the natural combinatorial construction of subword complexes introduced by A. Knutson and E. Miller, and describe how to use them to construct generalized cluster complexes and generalized associahedra. I will also say some words about their connections to repetition quivers, Auslander-Reiten quivers, and generalized cluster categories in finite types.

This talk is based on projects in collaboration with J.-P. Labbé, C. Ceballos, V. Pilaud, and N. Williams. (Received February 19, 2013)

1089-05-362 **Abbas Alhakim, Steve Butler*** (butler@iastate.edu) and **Ron Graham**. *De Bruijn sequences with varying combs.* Preliminary report.

De Bruijn sequences are 0-1 sequences of length 2^n which contain each 0-1 sequence of length n precisely once as a consecutive subsequence (where we are allowed to wrap around at the end). In this talk we report on investigations into what happens when we relax the requirement of being consecutive to being in some "comb", including constructions and various enumerations in special cases. (Received February 19, 2013)

1089-05-369 **Zajj Daugherty*** (zajj.b.daugherty@dartmouth.edu), 6188 Kemeny Hall, Hanover, NH 03755, and **Arun Ram**. *Combinatorics of affine Hecke algebras of type C.* Preliminary report.

Irreducible representations for the affine Hecke algebras of type C can be encoded combinatorially in a few different ways: as points and regions in affine space relative to certain hyperplane arrangements, as arrangements and fillings of boxes with certain rotational symmetries, and now as certain partitions and tableaux arising from the representations of the complex Lie algebra \mathfrak{gl}_n . In this talk I will describe these three combinatorial models and the correspondence between them. (Received February 19, 2013)

1089-05-371 **Kaisa Taipale*** (ktaipale@math.cornell.edu), **Elizabeth Beazley** and **Anna Bertiger**. *Computations in equivariant quantum cohomology of Grassmannians.* Preliminary report.

The (small) quantum cohomology of Grassmannians has been studied by a number of mathematicians, but its rich combinatorics continue to yield interesting connections and insights. In this talk we give a brief introduction to existing combinatorial techniques for computation in the (equivariant) (quantum) cohomology ring of a Grassmannian and present new methods that clarify the combinatorial structure of equivariant quantum Littlewood-Richardson coefficients. (Received February 19, 2013)

1089-05-384 **Jacques Verstraete*** (jacques@ucsd.edu), 9500 Gilman Drive, La Jolla, CA 92037, and **Bob Chen, Jeong Han Kim** and **Michael Tait**. *Coupon colorings of graphs.*

A k -coupon coloring of a graph G is a coloring of the vertices with k colors so that the neighborhood of each vertex contains a vertex of each of the k colors. The coupon chromatic number of G is the largest k for which a k -coupon coloring of G exists. The existence of a 2-coupon coloring of a graph corresponds to the so-called Property B of the hypergraph whose edges are the neighborhoods of vertices in the graph; in particular it is known that the coupon chromatic number of a 4-regular graph is always at least 2. We prove that every d -regular graph has coupon chromatic number asymptotically at least $d/(\log d)$ as $d \rightarrow \infty$, and that almost every d -regular graph has coupon chromatic number asymptotic to $d/(\log d)$ as $d \rightarrow \infty$. Explicit examples of regular graphs with such small coupon chromatic number are Paley graphs. In addition, we discuss coupon colorings of hamming cubes, for instance if Q_d denotes the d -dimensional hypercube then the coupon chromatic number is asymptotic

to d as $d \rightarrow \infty$ and exactly d when d is a power of two. Some open questions related to coding theory on coupon coloring of hypercubes are presented. (Received February 19, 2013)

1089-05-391 **Florian Pfender*** (florian.pfender@ucdenver.edu). *Complete subgraphs in multipartite graphs.*

Turán's Theorem states that every graph G of edge density $\|G\|/\binom{|G|}{2} > \frac{k-2}{k-1}$ contains a complete graph K^k and describes the unique extremal graphs. We give a similar Theorem for ℓ -partite graphs. For large ℓ , we find the minimal edge density d_ℓ^k , such that every ℓ -partite graph whose parts have pairwise edge density greater than d_ℓ^k contains a K^k . It turns out that $d_\ell^k = \frac{k-2}{k-1}$ for large enough ℓ , disproving a conjecture by Bondy, Chen, Thomassé and Thomassen. We also describe the structure of the extremal graphs. (Received February 19, 2013)

1089-05-392 **Andrzej Czygrinow, Louis DeBiasio, H. A. Kierstead*** (kierstead@asu.edu) and **Theodore Molla.** *Theorems and conjectures extending the Hajnal-Szemerédi Theorem to directed graphs.* Preliminary report.

An equitable coloring of a graph is a coloring in which any two color classes differ in size by at most one. The famous Hajnal-Szemerédi Theorem states that if $\Delta(G) < k$ then G has an equitable k -coloring. We investigate extensions of this theorem to directed graphs. The *total degree* of a vertex v in a directed graph is the sum $d^t(v) := d^-(v) + d^+(v)$ of its in- and out-degrees. Similarly, $\Delta^t(G)$ and $\delta^t(G)$ denote the maximum and minimum total degree of G . An *acyclic* coloring of a digraph is a coloring whose color classes may contain edges, but have no directed cycles. We prove that every directed graph G with $\Delta^t(G) < 2k$ has an equitable acyclic coloring. This implies that every directed graph H with $|H| = ks$ and $\delta(H) \geq 2 \cdot \frac{s-1}{s}|H| - 1$ can be tiled with transitive tournaments on s vertices. We also consider the problem of tiling with other tournaments, make some conjectures, and back them up with asymptotic results. (Received February 19, 2013)

06 ► Order, lattices, ordered algebraic structures

1089-06-17 **Jeffrey S. Olson***, Norwich University, Department of Mathematics, 158 Harmon Dr., Northfield, VT 05663. *Involutive residuated lattices based on modular and distributive lattices.* Preliminary report.

An involutive residuated lattice (IRL) is a lattice-ordered monoid with residual operations and a dualizing element. We show that a large class of self-dual lattices (including all finite ones) may be endowed with an IRL structure. On the other hand, we give examples of self-dual lattices which cannot admit IRLs possessing natural algebraic conditions, such as integrality. Finally, a characterization of all IRLs based on the modular lattices \mathbf{M}_n is provided. (Received November 25, 2012)

1089-06-30 **Yuri Movsisyan*** (yurimovsisyan@yahoo.com), Department of Mathematics and Mechanics, Yerevan State University, Alex Manoogian 1, 0025 Yerevan, Armenia. *Free De Morgan and Free Boole-De Morgan Algebras.*

It is commonly known that free Boolean algebra on n free generators is isomorphic to the Boolean algebra of Boolean functions of n variables. The free distributive lattice on n free generators is isomorphic to the lattice of monotone Boolean functions of n variables. In this paper we introduced the concept of De Morgan function and proved that the free De Morgan algebra on n free generators is isomorphic to the De Morgan algebra of De Morgan functions of n variables. This is a solution of the problem posed by B.I. Plotkin. Also we introduced the concept of quasi-De Morgan functions and proved that the free Boole-De Morgan algebra on n free generators is isomorphic to the Boole-De Morgan algebra of quasi-De Morgan functions of n variables. (Received January 13, 2013)

1089-06-95 **W. Charles Holland*** (charles.holland@colorado.edu). *Varieties of Lattice-Ordered Groups and Unital Lattice-Ordered Groups.*

A unital ℓ -group (G, u) is an ℓ -group G with an element $u \in G$ such that $e \leq u$, and for each $g \in G$ there exists a positive integer n such that $u^{-n} \leq g \leq u^n$.

I will talk about a couple of newly submitted papers on varieties (equationally defined classes) of ℓ -groups and unital ℓ -groups.

The Boolean variety \mathcal{B} of unital ℓ -groups is contained in every non-trivial variety of unital ℓ -groups. It has a covering layer of varieties, and uncountably many new ones of these have been discovered.

The abelian variety \mathcal{A} of ℓ -groups is also contained in every non-trivial variety of ℓ -groups. The metabelian variety \mathcal{A}^2 is all ℓ -groups of the form G with a convex normal sublattice subgroup H such that H is abelian, and

G/H is abelian. This contains a large collection of varieties. A variety V is minimal non-metabelian if V is not metabelian, but every variety properly contained in V is metabelian. I will describe all minimal non-metabelian varieties which contain no totally ordered non-abelian ℓ -groups. (Received February 04, 2013)

1089-06-114 **Tim Hannan** and **John Harding*** (jharding@nmsu.edu). *Automorphisms of Decompositions.*

It is common to consider the quotients of a structure as an ordered set. A typical example is the congruence lattice of an algebra. The binary direct product decompositions of a structure X can also be considered as an ordered structure $\text{FACT } X$. Here we say one binary decomposition $X \simeq A_1 \times A_2$ is less than another $X \simeq B_1 \times B_2$ if they can be built in an obvious way from a ternary decomposition.

We are interested in properties of these objects $\text{FACT } X$ both for their intrinsic interest and their connections to quantum logic. Here we begin the study of their automorphisms by considering the automorphism groups of $\text{FACT } V$ for a finite-dimensional vector space V , and of $\text{FACT } X$ for a finite set X . (Received February 07, 2013)

1089-06-251 **Jennifer Anne Brown*** (jennifer.brown@csuci.edu). *On pseudotree algebras and their underlying pseudotrees.* Preliminary report.

A pseudotree is a partially ordered set (T, \leq) such that for every $t \in T$, the set $T \downarrow t = \{r \in T : r \leq t\}$ is linearly ordered. If T is a pseudotree, the pseudotree algebra $\text{Treecalg}(T)$ is the subalgebra of $\mathcal{P}(T)$ generated by the cones $T \uparrow t = \{s \in T : s \geq t\}$, for $t \in T$. We characterize several cardinal invariants on $\text{Treecalg}(T)$ in terms of the structure of the underlying pseudotree T . (Received February 17, 2013)

1089-06-316 **Valentina Harizanov*** (harizanov@gwu.edu), Department of Mathematics, George Washington University, Washington, DC 20052. *Application of computability theory to a problem in topology.* Preliminary report.

The set of all infinite paths through a computable binary tree is an effectively closed set. These sets have been extensively studied in computability theory. Many important problems in computable mathematics can be viewed as problems about effectively closed sets. We will show how computability-theoretic complexity of members of effectively closed sets can be used to establish that the spaces of orders on countable orderable groups, both abelian and nonabelian, are homeomorphic to the Cantor set. (Received February 18, 2013)

1089-06-320 **William DeMeo*** (williamdemeo@gmail.com). *A general Dedekind transposition principle and examples of isotopic algebras with non-isomorphic congruence lattices.* Preliminary report.

We present a transposition principle that holds in all (not necessarily modular) lattices of equivalence relations. We then describe a class of finite unary algebras and use it to demonstrate that the difference in size of the congruence lattices of two finite isotopic algebras can be arbitrarily large. (Received February 18, 2013)

1089-06-326 **Nikolaos Galatos*** (ngalatos@du.edu). *Distributive integral residuated lattices have the FEP.*

A class of algebras \mathcal{K} is said to have the *finite embeddability property* (FEP) if for every algebra \mathbf{A} in \mathcal{K} and every *finite* partial subalgebra \mathbf{B} of \mathbf{A} , there exists a finite algebra \mathbf{D} in \mathcal{K} such that \mathbf{B} embeds into \mathbf{D} .

A *residuated lattice* is an algebra $\mathbf{A} = (A, \wedge, \vee, \cdot, \backslash, /, 1)$ where (A, \wedge, \vee) is a lattice, $(A, \cdot, 1)$ is a monoid and the following *residuation* property holds for all $x, y, z \in A$

$$xy \leq z \quad \text{iff} \quad x \leq z/y \quad \text{iff} \quad y \leq x \backslash z. \quad (\text{res})$$

A residuated lattice is called *distributive* if its lattice reduct is distributive; it is called *integral* if it satisfies $x \leq 1$ for all x .

We prove that every variety of integral, distributive residuated lattices axiomatized by identities that avoid divisions has the FEP. We obtain this result swiftly by using the general theory of residuated frames. The results are inspired by related work of C. Van Alten on the FEP for integral residuated lattices and of M. Kozak on the finite model property for distributive residuated lattices. (Received February 18, 2013)

1089-06-381 **Peter Jipsen*** (jipsen@chapman.edu), Chapman University, Von Neumann Hall, 545 W. Palm Ave, Orange, CA 92866. *Varieties of generalized hoops and integral GBL-algebras.* Preliminary report.

A *generalized hoop* $(A, \cdot, 1, \backslash, /)$ is a residuated partially ordered monoid in which $x \leq y$ iff $\exists u(x = uy)$ iff $\exists v(x = yv)$. Generalized hoops form a congruence distributive variety defined by, e.g., $x1 = x$, $x \backslash x = 1 = x/x$, $(xy) \backslash z = y \backslash (x \backslash z)$, $x/(yz) = (x/z)/y$, $(x/y)y = y(y \backslash x) = (y/x)x$. The term $(x/y)y$ defines a meet operation, hence is denoted by $x \wedge y$.

An *integral GBL-algebra* is a generalized hoop expanded with a join operation \vee such that (A, \wedge, \vee) is a lattice. Examples of such algebras are given by Brouwerian algebras and negative cones of ℓ -groups. A *hoop* is a commutative generalized hoop. We give a description of the HS-poset of all finite subdirectly irreducible generalized hoops, from which the lattice of finitely generated varieties of generalized hoops can be constructed as the lattice of downward closed subsets. A similar description for integral GBL-algebras is also given.

We show that the equational theory of basic hoops and BL-algebras can be decided efficiently using SMT-solvers. We also discuss the problem of whether generalized hoops have a decidable equational theory. (Received February 19, 2013)

08 ► *General algebraic systems*

1089-08-27 **Ralph McKenzie** and **Matthew Smedberg***, 1227H Stevenson Center, Vanderbilt University, Nashville, TN 37240. *Finitely decidable varieties admitting type 1 are residually finite*. Preliminary report.

We show that if \mathcal{V} is any locally finite variety such that the first-order theory of the finite members of \mathcal{V} is decidable, then \mathcal{V} contains only finitely many subdirectly irreducible algebras, all of which are finite. This result is known already for varieties omitting type 1; our proof establishes a number of necessary structural properties for a variety admitting type 1 to be finitely decidable. (Received January 10, 2013)

1089-08-43 **Clifford Bergman** (cbergman@iastate.edu), Department of Mathematics, Iowa State University, Ames, IA 50011, and **David Failing*** (dfailing@iastate.edu), Department of Mathematics, Iowa State University, Ames, IA 50011. *CSP for Commutative, Idempotent Groupoids*.

A theorem of Bulatov, Jeavons and Krokhin states that when the algebra associated with a core template does not lie in a Taylor variety, then the CSP for that template is NP-complete. In the same paper, the authors conjecture that in all other cases, the corresponding CSP is solvable in polynomial time. Maróti and McKenzie showed that an algebra generates a Taylor variety if and only if it has a k -ary weak near-unanimity (WNU) operation for some k ; this shifts the search for a proof of the *algebraic dichotomy conjecture* to focus on WNU operations.

A binary operation is a WNU precisely if it is commutative and idempotent, and a semilattice operation is known to be sufficient for the tractability of an algebra. Using Prover9 and the Universal Algebra Calculator, we investigate several weakenings of associativity and show that they too are sufficient for the tractability of a finite commutative, idempotent groupoid. In particular a finite CI-groupoid has a tractable CSP if it satisfies any of the following identities: $x(y(xz)) \approx x((yx)z)$, $x(y(yz)) \approx ((xy)y)z$, $x(yz) \approx (xy)(xz)$. A key tool is the theory of Plonka sums. Roughly speaking, we prove that a finite Plonka sum of finite algebras lying in a tractable variety is tractable. (Received January 17, 2013)

1089-08-97 **Tomas Feder**, **Pavol Hell** and **Benoit Larose***, benoit.larose@concordia.ca, and **Mark Siggers** and **Claude Tardif**. *Graphs, digraphs and k -NU polymorphisms*.

We describe, for each $k \geq 3$, a generating set for the class of simple graphs that admit a k -ary near-unanimity (NU) polymorphism. The result follows from an analysis of NU polymorphisms of strongly bipartite digraphs, i.e. whose vertices are either a source or a sink but not both: we show that the retraction problem for such a digraph has finite duality if and only if it admits an NU polymorphism. This allows the use of tree duals to generate the variety of digraphs admitting a k -NU polymorphism. (Received February 05, 2013)

1089-08-136 **Walter Taylor*** (walter.taylor@colorado.edu), 1452 North St, Boulder, CO 80304. *Topological algebras on finite simplicial complexes*. Preliminary report.

It would be nice to characterize the collection I of those equational theories Σ that have a topological model \mathbf{A} based on some finite simplicial complex A . This I defines a downward-closed proper subset of the interpretability lattice. I is the union of classes $I(A)$, one for each finite simplicial complex A , where $I(A)$ is the collection of theories that can be modeled on A .

In this survey talk we review some of the known higher (under interpretability) members of I , and mention one or two simple theories that are known not to lie in I .

Many questions can be asked about I and the individual classes $I(A)$. If $\Sigma \in I(A)$, is there a model \mathbf{A} whose operations are all piecewise multilinear? Does A model some $\Sigma' \geq \Sigma$, where all operations of Σ' are ternary? Binary? Does the ideal $I(A)$ have a generator that is a finite theory? Is there an easily described family of theories that generate I as a downward-closed set?

For Σ ranging over finite theories and A ranging over finite simplicial complexes, is the relation $\Sigma \in I(A)$ recursive in Σ and A (either jointly or in each variable separately)? (Received February 10, 2013)

1089-08-218 **Jonathan D.H. Smith*** (jds@iastate.edu), Department of Mathematics, 396 Carver Hall, Iowa State University, Ames, IA 50011. *Directional algebras and digroups*. Preliminary report.

Given a constant-free type, a directional type is obtained by pointing to each of the arguments of the original, undirected type. For each axiomatization of a variety of algebras of constant-free type, a corresponding directional variety is determined. Loday's dimonoids and digroups are shown to arise, using the general procedure, from suitably axiomatized semigroups and groups respectively. For quasigroups, various choices of equational bases lead to various varieties of directional quasigroups. Under one natural axiomatization, the variety of quasigroups is shown to be directionally complete, in the sense that the corresponding directional variety is again the variety of quasigroups. Another axiomatization yields $(4 + 2)$ -quasigroups. Digroups are then shown to be equivalent to a certain class of $(4 + 2)$ -quasigroups. (Received February 15, 2013)

1089-08-233 **Anna B. Romanowska*** (aroman@mini.pw.edu.pl), Warsaw University of Technology, Mathematics and Information Science, Koszykowa 75, 00-662 Warsaw, Poland, and **Gabor Cziedli**. *Algebraic closure of some generalized convex sets*.

Algebraic convex sets over a principal ideal subdomain R of the ring of real numbers are described as certain subreducts of affine spaces over R . Among them, geometric convex sets are described as the intersections of convex subsets of real affine spaces with corresponding affine spaces over R . We will introduce a concept of an algebraic closure of such convex sets and examine some of their properties. In particular, algebraic and topological closures of geometric convex subsets of finite dimensional affine spaces over R coincide. (Received February 16, 2013)

1089-08-274 **Matt Valeriote*** (matt@math.mcmaster.ca), 1280 Main Street West, Hamilton, Ontario L8S 4K1, Canada. *Congruence n -permutable varieties*.

It has been known for some time that if an idempotent variety V is congruence n -permutable for some $n > 1$ then V is not interpretable into the variety of distributive lattices. We show that the converse is true, by proving that if an idempotent variety V is not congruence n -permutable for any $n > 1$, then V contains a 2-element algebra with universe $\{0, 1\}$ whose operations are all monotone with respect to the ordering $0 < 1$. We will also discuss other characterizations of congruence n -permutable varieties.

This is joint work with Ross Willard. (Received February 18, 2013)

1089-08-350 **Alexander Wires*** (alexander.d.wires@vanderbilt.edu), 1326 Stevenson Center, Vanderbilt University, Nashville, TN 37240. *A disjunction characterizing varieties with a weak difference term*. Preliminary report.

We provide a characterization for varieties with a weak difference term similar to the disjunction given for congruence meet-semidistributive varieties established by Ross Willard in "A finite basis theorem for residually finite, congruence meet-semidistributive varieties" (2000). We consider some applications of the characterization including new proofs of some well-known results. (Received February 19, 2013)

1089-08-354 **Steve Seif*** (swseif01@louisville.edu). *Finite lattices that force transitivity of G -Set representations*.

A finite lattice L is said to be *G -Set transitivity forcing* if all representations of it by G -Set are transitive. How likely is that a finite lattice is G -Set transitivity forcing? This question will be discussed, along with some results. The structure of finite lattices that are representable by intransitive flat M -Sets (a class that includes G -Sets) will be described. (Received February 19, 2013)

1089-08-388 **Matthew D Moore*** (notmattmoore@gmail.com). *The Undecidability of the Definability of Principal Subcongruences*.

For each Turing machine \mathcal{T} , we construct an algebra $\mathbb{A}'(\mathcal{T})$ such that the variety generated by $\mathbb{A}'(\mathcal{T})$ has definable principal subcongruences if and only if \mathcal{T} halts, thus proving that the property of having definable principal subcongruences is undecidable. Using this, we present another proof that A. Tarski's finite basis problem is undecidable. (Received February 19, 2013)

1089-08-396 **George F McNulty*** (mcnulty@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208. *Every Finite Lattice is Finitely Based*. Preliminary report.

Ralph McKenzie said so in 1968. The story does on. (Received February 19, 2013)

1089-08-405 **Ralph N McKenzie*** (ralph.n.mckenzie@vanderbilt.edu). *Malcev families of quasivarieties closed under join or Malcev product.*

We show that if \mathcal{K} and \mathcal{L} are quasivarieties of idempotent algebras satisfying P where P is any of the properties next listed, then the Malcev product of \mathcal{K} and \mathcal{L} satisfies P , and therefore the variety generated by $\mathcal{K} \cup \mathcal{L}$ satisfies P . These properties are: “has a Taylor term”, “has a cube term”, “has meet-semi-distributive congruence lattices”, “has semi-distributive congruence lattices”, “has n -permuting congruences, for some integer $n > 1$ ”, “has a non-trivial congruence identity”.

On the other hand, we exhibit examples of finite idempotent algebras \mathbf{A} and \mathbf{B} , each of which generates a variety satisfying Q , while $\mathbf{A} \times \mathbf{B}$ does not, where Q is any one of: “has a Malcev term”, “has Jónsson operations”, “has Day operations”.

These are joint results with Ralph Freese. (Received February 20, 2013)

11 ► Number theory

1089-11-16 **Jennifer Park*** (jmypark@math.mit.edu), 77 Massachusetts Ave., Cambridge, MA 02139. *A symmetric version of Chabauty’s method on families of hyperelliptic curves.* Preliminary report.

It is known since Faltings that hyperelliptic curves have finitely many rational points, and several heuristics suggest that 100% of them have no rational points apart from ∞ . Using similar heuristics, we expect 100% of the hyperelliptic curves to have no nontrivial degree- d points. We will discuss how Chabauty’s method could be applied to families of hyperelliptic curves to obtain a bound on the number of non-trivial degree- d points on a certain family of hyperelliptic curves. This can be combined with the recent result of Bhargava and Gross on the distribution of 2-Selmer elements of hyperelliptic curves, allowing one to take the first steps towards describing the statistics of non-trivial degree- d points. (Received November 20, 2012)

1089-11-18 **Nathan Paul Wakefield*** (wakefien@colorado.edu). *Primitive Divisors in Generalized Iterations of Chebyshev Polynomials.*

Let $(g_i)_{i \geq 1}$ be a sequence of Chebyshev polynomials, each with degree at least two, and define $(f_i)_{i \geq 1}$ by the following recursion: $f_1 = g_1$, $f_n = g_n \circ f_{n-1}$ for $n \geq 2$. Choose $\alpha \in \mathbb{Q}$ such that $\{g_1^n(\alpha) : n \geq 1\}$ is an infinite set. The main result of this talk is as follows: If $f_n(\alpha) = \frac{A_n}{B_n}$ is written in lowest terms, then for all but finitely many $n > 0$ the numerator A_n has a primitive divisor; that is, there is a prime p which divides A_n but does not divide A_i for any $i < n$. (Received November 27, 2012)

1089-11-24 **Charles L Samuels*** (clsamuels@okcu.edu), Oklahoma City University, Department of Mathematics, 2501 N. Blackwelder, Oklahoma City, OK 73102. *Metric height functions on an Abelian group.*

Recent work of the author explored a modified version of the Mahler measure that is well-defined on the group of non-zero algebraic numbers modulo the roots of unity. The construction that leads to these metric Mahler measures may be applied to functions other than the Mahler measure. We describe this generalization and provide analogs of known results in the abstract case. This exploration provides a resolution to a conjecture on the original metric Mahler measure. (Received January 04, 2013)

1089-11-33 **Sanju Velani*** (slv3@york.ac.uk). *Multiplicative and Inhomogeneous Diophantine Approximation.*

A result of Gallagher implies that for almost every $(\alpha, \beta) \in \mathbf{R}^2$

$$\liminf_{q \rightarrow \infty} q \log^2 q \|q\alpha\| \|q\beta\| = 0.$$

In the first part I will try to convince you that this result can be improved and thus expect more from Littlewood’s Conjecture – at least from a metrical point of view. In the second part, I will investigate concrete situations in which inhomogeneous Diophantine approximation results can be derived from their homogeneous counterparts. For example, for any real number γ , let \mathbf{Bad}_γ denote the inhomogeneous badly approximable set consisting of real numbers α for which $\liminf_{q \rightarrow \infty} q \|q\alpha - \gamma\| > 0$. Then the basic construction that proves the homogeneous statement that \mathbf{Bad}_0 is of full dimension can be naturally adapted to show that $\dim \mathbf{Bad}_0 = 1$. Moreover, the transference idea enables us to show that any countable intersection of the simultaneous badly approximable sets $\mathbf{Bad}_\gamma(i, j)$ in the plane is of full dimension – the inhomogeneous Schmidt Conjecture. (Received January 15, 2013)

1089-11-59 **Amy Feaver*** (amy.feaver@colorado.edu). *norm-Euclidean multiquadratic number fields*. Preliminary report.

A number field is called norm-Euclidean if its ring of integers is Euclidean with respect to the absolute value of the norm function of the field. We study imaginary multiquadratic number fields of degree at least 8, which can be expressed as $\mathbb{Q}(\sqrt{-a_1}, \dots, \sqrt{-a_n})$ for distinct square-free integers a_1, \dots, a_n and $n \geq 3$. We find that for $n \geq 4$, no imaginary multiquadratic fields are norm-Euclidean. For the case of $n = 3$, we have that three of the fields are norm-Euclidean, and if there are more imaginary triquadratic fields which satisfy this property, then there are at most five more. (Received January 25, 2013)

1089-11-71 **Bill Mance*** (mance@unt.edu), Department of Mathematics, General Academics Building 435, 1155 Union Circle #311430, Denton, TX 76203-5017. *Construction of normal numbers through homeomorphisms of Cantor spaces*.

We discuss some recent theoretical developments which allow for techniques from differential topology, fractal geometry, and number theory to work together to construct normal numbers with certain unexpected and pathological properties. The main example will be a construction of a basic sequence Q and a number that is Q -distribution normal and Q -ratio normal but not Q -normal. Time permitting, we will also sketch constructions of basic sequences Q and numbers that are Q -normal of order k and not Q -normal of orders 1, 2, ..., $k - 1$. (Received February 12, 2013)

1089-11-77 **Alexandru Buium***, Department of Mathematics and Stat, 1 University of New Mexico, Albuquerque, NM 87131, and **Taylor Dupuy**, Department of Mathematics and Statistics, University of New Mexico, Albuquerque, NM 87131. *Arithmetic differential Galois theory and dynamics on projective space*. Preliminary report.

Differential equations have an arithmetic analogue in which derivatives are replaced by Fermat quotients. A natural question is then to ask for an analogue, in this arithmetic context, of linear differential equations and their differential Galois theory. Such an analogue is being introduced and studied; it turns out that the resulting theory is closely intertwined with the arithmetic of dynamical systems on projective space. (Received February 01, 2013)

1089-11-80 **Kiran S. Kedlaya*** (kedlaya@ucsd.edu). *Sato-Tate groups of motives*.

The Sato-Tate group of a motive defined a number field is a compact Lie group whose construction is closely related to the Mumford-Tate group and the motivic Galois group. It may be thought of as an analogue of the ℓ -adic monodromy group for an “arithmetic family”, where what varies is the choice of a prime ideal rather than a fibre of a geometric morphism, and the analogue of Deligne’s equidistribution theorem is the generalized Sato-Tate conjecture. We discuss the problem of the classification of possible Sato-Tate groups of 1-motives associated to abelian varieties (especially in dimensions 2 and 3) and some other cases. Includes joint work with Francesc Fité, Víctor Rotger, and Andrew Sutherland. (Received February 01, 2013)

1089-11-96 **Cassie L Williams*** (willi5c1@jmu.edu), James Madison University, Harrisonburg, VA. *Enumerating abelian varieties using matrix groups*. Preliminary report.

The Frobenius endomorphism of an abelian variety A/\mathbb{F}_q acts as a symplectic similitude on the torsion subgroups $A[\ell^n](\overline{\mathbb{F}}_q)$. In 2003, Gekeler used an equidistribution assumption on the elements of $\mathrm{GL}_2(\mathbb{Z}/\ell^r)$ to show that the number of elliptic curves with certain characteristics is related, via results of Sato-Tate and the class number, to the Euler factors of the L -function of a quadratic imaginary field. By determining the sizes of conjugacy classes of Frobenius elements in the group GSp_4 and applying a theorem of Everett Howe, we extend Gekeler’s heuristic to abelian surfaces with complex multiplication. (Received February 05, 2013)

1089-11-108 **Soroosh Yazdani*** (soroosh.yazdani@uleth.ca), Department of Math and CS, University of Lethbridge, 4401 University Drive, Lethbridge, Alberta T1K 3M4, Canada. *Perfect Powers in Elliptic Nets*.

An elliptic net is function from a finite rank free Abelian group to a ring (usually integers), satisfying a certain recurrence conditions. These objects are interesting since they are closely related to the denominator of linear combinations of points on an elliptic curve. In this talk we show that for certain nets

$$W : \mathbb{Z}^n \rightarrow \mathbb{Z}$$

the Diophantine equation $W(a) = z^n$ has no solution for $n > 1$. (Received February 06, 2013)

1089-11-109 **Alon Levy, Michelle Manes and Bianca Thompson*** (bat7@hawaii.edu). *Uniform bounds for pre-periodic points in families of twists.*

Let ϕ be a morphism of \mathbb{P}^N defined over a number field K . We prove that there is a bound B depending only on ϕ such that every twist of ϕ has no more than B K -rational preperiodic points. (This result is analogous to a result of Silverman for abelian varieties.) For two specific families of quadratic rational maps over \mathbb{Q} , we find the bound B explicitly. (Received February 06, 2013)

1089-11-127 **Seyfi Turkelli*** (s-turkelli@wiu.edu), Department of Mathematics, Western Illinois University, Macomb, IL 61455. *Lower Bounds for the Cohomology of Bianchi Groups.*

Bianchi groups are the congruence subgroups of $SL(2, O)$ where O is the ring of integers of an imaginary quadratic field. The cohomology of Bianchi groups with certain coefficient modules are in fact the space of certain automorphic forms of cohomological type.

Very little is known about the cohomology of Bianchi groups. I will talk about a recent result on the dimension of the cohomology of Bianchi groups. More precisely, I will talk about a method, originally due to Harder, and how it is used to give a lower bound for the dimension of these cohomology spaces. I plan to finish the talk with new asymptotic results and some open problems.

This is a joint work with M. H. Sengun. (Received February 09, 2013)

1089-11-129 **David Zywina*** (zywina@math.ias.edu). *Elliptic surfaces and the Inverse Galois Problem.*

The Inverse Galois Problem asks whether every finite group G occurs as the Galois group of some extension of \mathbb{Q} , i.e., whether there is a Galois extension K/\mathbb{Q} such that $Gal(K/\mathbb{Q})$ is isomorphic to G . This problem is still wide open, even in the special case of simple groups.

By studying the Galois action on the étale cohomology of some well-chosen families of elliptic surfaces, we will prove many new cases of the Inverse Galois problem. In particular, we will explain why the simple groups $PSp_4(\mathbb{F}_p)$, with p an odd prime, occur as Galois groups of extensions of \mathbb{Q} . The key ingredients are a big monodromy result and some known cases of the Birch and Swinnerton-Dyer conjecture. (Received February 09, 2013)

1089-11-141 **Rafe Jones and Michelle Manes*** (mmanes@math.hawaii.edu), University of Hawaii, Department of Mathematics, 2565 McCarthy Mall, Keller 401A, Honolulu, HI 96822. *Discriminants and Galois groups for iterated rational functions.*

Let f be a rational function of degree two defined over a number field K . In this talk we consider the extensions K_n obtained by adjoining the set $f^{-n}(0)$ to K , with a special interest in computing the Galois group of K_n/K . We show that the critical orbits of f determine the discriminants of the K_n , and these in turn can sometimes be used to show $Gal(K_n/K)$ is as large as possible. We apply the results to give the first non-polynomial example of a function with $Gal(K_n/K)$ as large as possible, and we suggest a one-parameter family of rational functions for further investigation. (Received February 11, 2013)

1089-11-145 **Wolfgang M Schmidt*** (schmidt@colorado.edu). *Some Topics in Diophantine Approximation.*

We will talk on simultaneous approximation, including approximation with sign constraints, various approximation exponents, and Geometry of Numbers involving orbits of lattices (Received February 11, 2013)

1089-11-163 **Hugh C Williams*** (hwilliam@ucalgary.ca) and **Richard K Guy**. *Some Interesting Linear Divisibility Sequences of Order Four.*

A sequence of rational integers is said to be a divisibility sequence if the m th term always divides the n th term whenever m divides n . If the divisibility sequence also satisfies a linear recurrence relation, it is said to be a linear divisibility sequence of order k , where k is the degree of its characteristic polynomial. The best known example of a linear divisibility sequence of order 2 is the Lucas sequence, one particular instance of which is the famous Fibonacci sequence. In such sequences we know that if a given prime p divides the n th term, then n must be divisible by a certain integer r , depending on p , called the rank of apparition of p . However, in the case of divisibility sequences of order greater than 2 there can in general be more than one rank of apparition with respect to a given prime p . In their extension of the Lucas functions to order 4 linear recursions, Williams and Guy (2011) showed that order 4 analogs of the Lucas sequence can have no more than two ranks of apparition for a given prime p and frequently have two such ranks. In this paper we investigate the problem of determining for these sequences those which have only one rank of apparition for any prime p and those which must have two ranks infinitely often. (Received February 12, 2013)

1089-11-166 **Stephan Ramon Garcia*** (stephan.garcia@pomona.edu), Department of Mathematics, 610 N. College Ave, Claremont, CA 91711. *Supercharacters on abelian groups.*

The theory of supercharacters, which generalizes classical character theory, was recently developed in an axiomatic fashion by P. Diaconis and I.M. Isaacs, based upon earlier work of C. André. When this machinery is applied to abelian groups, a variety of applications emerge. In particular, we develop a broad generalization of the discrete Fourier transform along with several combinatorial tools. This perspective also leads us to consider certain exponential sums which produce visually striking patterns of great complexity and subtlety. (Received February 12, 2013)

1089-11-185 **Lior Fishman, Dmitry Kleinbock, Keith Merrill*** (merrill12@brandeis.edu) and **David Simmons.** *Intrinsic Approximation on Quadratic Varieties.*

Let Q be a rational quadratic form, and let X be the level set $Q(x) = 1$. We analyze the approximation of points in X by rational points in X , proving analogues of classical results on the density of $\mathbb{Q} \subset \mathbb{R}$. Specifically we prove a Dirichlet statement that every point is approximable, the optimality of this approximation via the existence of badly approximable points, and a Khinchin statement that almost every (resp. almost no) point is sufficiently well approximable depending on whether a certain sum diverges (resp. converges). We will also discuss when the Dirichlet theorem can be strengthened, depending on certain algebraic and geometric data of the form Q .

This work complements and improves on previous results, particularly those due to Drutu and more recently to Gorodnik, Ghosh, and Nevo. (Received February 14, 2013)

1089-11-194 **Alia Hamieh*** (ahamieh@math.ubc.ca), Department of Mathematics, The University of British Columbia, Room 121, 1984 Mathematics Road, Vancouver, B.C. V6T 1Z2, Canada. *Ternary Quadratic Forms and Half-Integral Weight Modular Forms.*

Let k be a positive integer such that $k \equiv 3 \pmod{4}$, and let N be an odd positive square-free integer. In this talk, we show how to compute a basis for the two-dimensional subspace $S_{\frac{k}{2}}(\Gamma_0(4N), F)$ of half-integral weight modular forms associated, via the Shimura correspondence, to a newform $F \in S_{k-1}(\Gamma_0(N))$, which satisfies $L(F, \frac{1}{2}) \neq 0$. This is accomplished by using a result of Waldspurger, which allows one to produce a basis for the forms that correspond to a given F via local considerations, once a form in the Kohnen space has been determined. (Received February 14, 2013)

1089-11-195 **erez nesharim*** (ereznesh@gmail.com). *Absolute Schmidt's Game With Regrets.* Preliminary report.

Motivated by Jinpeng An's recent proof of winning of $Bad(i, j)$, we describe a variant of the absolute Schmidt's game and show that $Bad(i, j)$ is actually winning for this game. This enables us to conclude results about intersection with fractals and invariance of $Bad(i, j)$. (Received February 14, 2013)

1089-11-198 **Richard K. Guy*** (rkcg@cpsc.ucalgary.ca), Calgary, Alberta T2N 1N4, Canada, and **Hugh C. Williams** (hwilliam@ucalgary.ca), Calgary, Alberta T2N 1N4, Canada. *Linear divisibility sequences.* Preliminary report.

This abstract may be read in conjunction with abstract number 1089-11-163. The Lucas-Lehmer theory has given us a good understanding of **divisibility sequences** which satisfy a second order linear recurrence relation. For example, the (unique) **rank of apparition** of a prime p is a divisor of $p - \left(\frac{\Delta}{p}\right)$ where $\left(\frac{\Delta}{p}\right)$ is the Legendre symbol and Δ is the discriminant of the characteristic polynomial. However, we do not know which divisor. Hugh Williams has generalized the theory of Lucas functions to cover fourth order sequences, where, in some cases, primes may have two ranks of apparition, neither of which divides the other. We do not know if we have found all fourth order sequences, nor do we always know, given a fourth order recurrence relation, what sets of initial values, if any, generate fourth order divisibility sequences. Even less is known of higher order divisibility sequences, of which some examples are forthcoming. (Received February 14, 2013)

1089-11-199 **Clayton Petsche*** (petschec@math.oregonstate.edu), Oregon State University, and **Brian Stout** (bstout@gc.cuny.edu), CUNY Graduate Center. *On quadratic rational maps with prescribed good reduction.*

Given a number field K and a finite set S of places of K , the first main result of this paper shows that the quadratic rational maps $\phi : \mathbb{P}^1 \rightarrow \mathbb{P}^1$ defined over K which have good reduction at all places outside S comprise a Zariski-dense subset of the moduli space \mathcal{M}_2 parametrizing all isomorphism classes of quadratic rational maps. We then consider quadratic rational maps with double unramified fixed-point structure, and our second main result establishes a geometric Shafarevich-type non-Zariski-density result for the set of such maps with good

reduction outside S . We also prove a variation of this result for quadratic rational maps with unramified 2-cycle structure. (Received February 14, 2013)

1089-11-214 **Cameron L. Stewart*** (cstewart@uwaterloo.ca), Department of Pure Mathematics, University of Waterloo, Waterloo, Ontario N2L3G6, Canada. *On prime factors of binary recurrence sequences.*

In this talk we shall give some estimates for the size of the greatest prime factor of the n -th term of a non-degenerate binary recurrence sequence of integers. (Received February 15, 2013)

1089-11-241 **Wei Ho*** (who@math.columbia.edu). *Ranks of Elliptic Curves over Quadratic Extensions.* We will recall how parametrizations of Selmer elements for elliptic curves by orbits of representations of algebraic groups, combined with counting techniques coming from the geometry of numbers, allow us to compute the average size of Selmer groups for elliptic curves in various families. We will discuss an example for which such an average gives a new application to ranks of elliptic curves over quadratic fields. This is joint work with Manjul Bhargava. (Received February 16, 2013)

1089-11-242 **Jing-Jing Huang*** (huang@math.toronto.edu). *The distribution of rational points near planar curves and metric Diophantine approximation.*

Since Kleinbock and Margulis established the fundamental Baker-Sprindžuk conjecture concerning homogeneous Diophantine approximation on manifolds in 1998, some tremendous progress has been made toward the much stronger Khintchine-Jarnik type theorem for non-degenerate manifolds in the last decade or so. In particular, the metric theory of planar curves has been well understood now, thanks to Vaughan and Velani for the convergence theory and Beresnevich, Dickinson and Velani for the divergence theory. Both of these two results rely on estimates (upper and lower bounds of the conjectured order of magnitude) on the number of rational points with small denominators which are near the curve (actually the convergence theory concerns the upper bound and the divergence theory concerns the lower bound). However the two proofs differ quite significantly in nature. In this talk, I will prove that the above mentioned counting function actually satisfies an asymptotic formula and hence this yields a unified proof of both results. (Received February 16, 2013)

1089-11-262 **Paul Fili*** (pfili@z.rochester.edu), **Zachary Miner** and **Clayton Petsche**. *Heights in fields with splitting conditions.*

It is well-known that fields satisfying splitting conditions like being totally real satisfy a Bogomolov property, namely, the value of the height is bounded away from zero with a finite number of exceptions. In this talk we will discuss the connection of these results with equidistribution and potential theory at both archimedean and non-archimedean places, and present some recent results of the authors which improve the best known previous results. (Received February 17, 2013)

1089-11-264 **Nigel Boston*** (boston@math.wisc.edu), Department of Mathematics, University of Wisconsin, Madison, WI 53706. *A refined conjecture on factoring iterates of polynomials over finite fields.*

In previous work Rafe Jones and I studied the factorization of iterates of a quadratic polynomial over a finite field. Their shape has consequences for the images of Frobenius elements in the corresponding Galois groups (which act on binary rooted trees). We found experimentally that the shape of the factorizations can be described by an associated Markov process, we explored the consequences to arboreal Galois representations, and conjectured that this would be the case for every quadratic polynomial. Last year I gave an undergraduate, Shixiang Xia, the task of accumulating more evidence for this conjecture and was shocked since one of his examples behaved very differently. We have now understood this example and come up with a modified model to explain it. (Received February 17, 2013)

1089-11-286 **Nigel Boston*** (boston@math.wisc.edu), Department of Mathematics, University of Wisconsin, Madison, WI 53706. *Non-abelian Cohen-Lenstra heuristics- moments version.*

In 1983, Cohen and Lenstra observed that the frequency with which a given abelian p -group A (p odd) arises as the p -class group of an imaginary quadratic field K is apparently proportional to $1/\#\text{Aut}(A)$. The group A is isomorphic to the Galois group of the maximal unramified abelian p -extension of K . In work with Michael Bush and Farshid Hajir, I generalized this to non-abelian unramified p -extensions of imaginary quadratic fields. Here I describe new work with Daniel Ross and Melanie Wood giving the moments version of the conjecture, which concerns the expected number of G -extensions of an imaginary quadratic field, where G is a (possibly non-abelian) p -group. (Received February 18, 2013)

1089-11-287 **Chantal David*** (cdavid@mathstat.concordia.ca). *Distribution of zeta zeroes of Artin-Schreier curves.*

We discuss in this talk statistics for the zeroes of zeta functions of Artin-Schreier curves over finite fields, i.e. curves of the type $Y^p - Y = f(X)$ for a rational function $f(X)$ in the function field $\mathbf{F}_q(X)$, where q is a power of the prime p . Because of the special role played by the characteristic of the base field in the definition of Artin-Schreier curves, one can write their zeta functions in terms of exponential sums. This was first used by Entin to study the variation of the zeroes and the powers of the zeroes for the Artin-Schreier curves of p -rank 0. Other statistics were obtained for the same family by A. Bucur, C. David, B. Feigon, M. Lalin and K. Sinha. More recently, similar statistics were obtained for other families of Artin-Schreier curves corresponding to different strata of the p -rank stratification. We show in this talk that for all families considered, the distribution of the (properly normalized) zeroes of the zeta function in intervals follows a Gaussian distribution.

This is joint work with A. Bucur, B. Feigon and M. Lalin. This talk will be the second part of a joint talk following immediately the first part given by A. Bucur in the same session. (Received February 18, 2013)

1089-11-302 **Adam D Towsley*** (atowsley@gc.cuny.edu), 365 5th Avenue, New York, NY 10016, and **Xander Faber.** *Newton's Method in Global Fields.*

Classically Newton's method is used to approximate roots of complex valued functions f by creating a sequence of points that converges to a root of f in the usual topology. For any global field K we completely describe the conditions under which Newton's method applied to a squarefree polynomial f with K -coefficients will succeed in finding a root of f in the v -adic topology for infinitely many places v of K . Furthermore, we show that Newton approximation sequence fails to converge v -adically for a positive density of places v . (Received February 18, 2013)

1089-11-305 **Shabnam Akhtari*** (akhtari@uoregon.edu), Eugene, OR. *Thue inequalities with few solutions.* Preliminary report.

Let $F(x, y)$ be a binary form of degree $n \geq 3$ with integer coefficients and non-zero discriminant. I will use different techniques from Diophantine analysis to study the number of integer solutions (x, y) to Thue inequality

$$|F(x, y)| \leq m,$$

where m is an integer. It is well-known that the number of solutions to this inequality is finite. If the integer m is small enough in terms of the discriminant of F then we may obtain an upper bound for the number of solutions that only depends on n , the degree of F . (Received February 18, 2013)

1089-11-306 **David Grant*** (grant@colorado.edu), Department of Mathematics, University of Colorado at Boulder, Boulder, CO 80309-0395. *Resultants of division polynomials.*

We will discuss how to compute resultants of elliptic division polynomials, and applications to reciprocity laws and elliptic units. (Received February 18, 2013)

1089-11-315 **Patrick Ingram*** (pigram@rams.colostate.edu), Department of Mathematics, Colorado State University, Fort Collins, CO 80521. *The filled Julia set of a Drinfeld module.*

One can view a Drinfeld module over a local function field as a dynamical system, and associate to it a filled Julia set in the usual sense. Over a global function field, one can then define the corresponding object over the ring of finite adeles. We present a conjecture about the structure of this adelic filled Julia module which implies the uniform boundedness of torsion on Drinfeld modules, and prove this conjecture in certain special cases. (Received February 18, 2013)

1089-11-317 **Rachel Davis***, Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706. *Galois Representations Associated to a Metabelian Cover of the ℓ^n -torsion points of Elliptic Curves.* Preliminary report.

In the classical case of ℓ -adic Galois representations associated to elliptic curves, there are theorems concerning when the images are surjective. These representations are representations to the automorphism group of the abelian group of all of the ℓ -power-division points.

Grothendieck and others have developed a theory of Galois representations to an automorphism group of a free pro- ℓ group. The free pro- ℓ group is a cover of the ℓ -power division points that is much larger. This is the theory of the étale fundamental group. These much more general representations contain all of the information of the ℓ -adic representation. However, there is less concrete information known about the sizes of the images and the images of Frobenius.

As a first step to understanding the étale fundamental group, I will consider a specific metabelian cover of the ℓ^n torsion points of an elliptic curve and study the representations to the automorphism group of this group.

I am interested in the sizes of the images and the images of Frobenius for these representations. (Received February 18, 2013)

1089-11-329 **Alina Bucur*** (alina@math.ucsd.edu), **Chantal David**, **Brooke Feigon** and **Matilde Lalin**. *Statistics for Artin-Schreier covers over finite fields.*

This is the first part of a two-talk sequence regarding the statistics for points and zeroes of zeta functions of Artin-Schreier covers over finite fields. The second talk in the sequence will be given by Chantal David immediately following this presentation. The Artin-Schreier are given by equations of the type $y^p - y = f(x)$ where $f(x)$ is a rational function over a finite field of characteristic p . The special shape of the zeta function was used by first by Entin and then by Bucur, David, Feigon, Lalin and Sinha to study the variation of the zeroes of the zeta functions for the family of Artin-Schreier covers of p -rank 0 in various regimes. Today we will be concerned with similar statistics for other p -rank strata of the moduli space of Artin-Schreier covers. We will place special emphasis on the maximal p -rank stratum. (Received February 18, 2013)

1089-11-330 **Ying Zong*** (zongying@math.utoronto.ca), 40 St. George Street, Toronto, Ontario M5S 2E4, Canada, and **V Kumar Murty** (murty@math.utoronto.ca), 40 St George Street, Toronto, ON M5S 2E4, Canada. *Splitting of abelian varieties, elliptic minuscule pairs.*

We partially answer, in terms of monodromy, Murty's question: given an absolutely simple abelian variety over a number field, does it specialize to simple abelian varieties at a set of places of positive Dirichlet density? The answer is based on the classification of pairs (G, V) , consisting of a semi-simple algebraic group G over a p -adic local field, and an absolutely irreducible representation V of G , such that G admits some maximal torus irreducible on V . (Received February 18, 2013)

1089-11-358 **Jacob Tsimerman***, 238 Columbia St., 2W, Cambridge, MA 02139. *Most Abelian Varieties over the \mathbb{Q} are not Isogenous to a Jacobian.*

We construct families of Abelian Varieties over \mathbb{Q} for which most members are not isogenous to a Jacobian Variety. Our methods combine a recent result of D.Zywina on monodromy for Abelian Varieties in families, with an equidistribution result for Hecke operators. (Received February 19, 2013)

1089-11-364 **C. Douglas Haessig*** (chaessig@math.rochester.edu), University of Rochester, Mathematics dept., 915 Hylan Building, RC Box 270138, Rochester, NY 14627. *Dwork's unit root L-function for toric exponential sums.* Preliminary report.

We will present some recent results on Dwork's unit root L-function for toric exponential sums. (Received February 19, 2013)

1089-11-370 **Hilary Smallwood***, Department of Mathematics, Louis R. Weber Building, 841 Oval Drive, Fort Collins, CO 80523. *Counting Abelian Surfaces with Real Multiplication over \mathbb{F}_q .* Preliminary report.

Given a simple abelian surface, A/\mathbb{F}_q , the endomorphism algebra, $\text{End}(A) \otimes \mathbb{Q}$ contains a real quadratic subfield. For squarefree $d > 0$, we estimate the number of principally polarized abelian surfaces A/\mathbb{F}_q such that $\mathbb{Q}(\sqrt{d}) \subset \text{End}(A) \otimes \mathbb{Q}$, and show that this quantity is approximately $q^{5/2}$. (Received February 19, 2013)

1089-11-377 **Michael A. Bennett*** (bennett@math.ubc.ca), 1984 Mathematics Road, Department of Mathematics, U.B.C., Vancouver, B.C. V6T 1Z2, Canada. *Gaps between squares and other perfect powers.* Preliminary report.

We discuss the arithmetic of the (nonzero) gaps between squares and other perfect powers, emphasizing situations where the primitive divisor theorem of Bilu-Hanrot-Voutier is not applicable. (Received February 19, 2013)

1089-11-383 **Holley Friedlander**, **Derek Garton** and **Beth Malmskog*** (elisabeth.malmskog@coloradocollege.edu), 818 Cache La Poudre, Colorado Springs, CO 80903, and **Rachel Pries** and **Colin Weir**. *The a -numbers of Jacobians of Suzuki Curves.*

For $m \in \mathbb{N}$, let S_m be the Suzuki curve defined over $\mathbb{F}_{2^{2m+1}}$. It is well-known that S_m is supersingular, but the p -torsion group scheme of its Jacobian is not known. The a -number is an invariant of the isomorphism class of the p -torsion group scheme. In this talk, I will discuss joint work in which we computed a closed formula for the a -number of S_m using the action of the Cartier operator on H_0 .

(Received February 19, 2013)

1089-11-395 **Mark Bauer, Richard Guy, Michael Wanless and Coiln Weir*** (cjweir@ucalgary.ca). *Extending Zagier's Theorem on Continued Fractions and Class Numbers*. Preliminary report.

If $p = 3 \pmod{4}$ is prime and the class number $h(\mathbb{Q}(\sqrt{p})) = 1$ then a somewhat classical theorem of Zagier provides a formula for $h(\mathbb{Q}(\sqrt{-p}))$ in terms of the negative continued fraction expansion of \sqrt{p} . We will present a generalization of this result to a family of non-prime radicands. We will also discuss our work in progress in combining this theorem with particular prime producing polynomials. (Received February 19, 2013)

1089-11-403 **Jordan S. Ellenberg*** (ellenber@math.wisc.edu). *Monodromy groups, connected components, and averages*.

I will give an overview of some work in arithmetic statistics centered on the interplay between geometric monodromy groups, connected components of moduli spaces, and averages in arithmetic counting problems. Warning: both big monodromy and small monodromy will appear. (Received February 19, 2013)

13 ► Commutative rings and algebras

1089-13-9 **Trevor McGuire*** (tmcgui1@lsu.edu). *A Combinatorial Algorithm for Generating Free Resolutions of Ideals with Binomial and Monomial Generators*.

Free resolutions of $S = k[x_1, \dots, x_n]$ -modules are widely studied. In the field of combinatorial commutative algebra, resolutions of S-ideals generated only by monomials or only by binomials have been given a combinatorial description in terms of simplicial complexes. In fact, simple algorithms have been given that generate these free resolutions. In this talk, we will describe a combinatorial algorithm that can generate a free resolution of an S-ideal of an S-ideal that is generated by both monomial and binomial terms. This algorithm is based on the newly defined Lattice Tranlasted Buchberger Graph, which is a generalization of the Buchberger graph one uses to resolve a monomial S-ideal. (Received September 21, 2012)

1089-13-78 **Thomas Lam*** (tflam@umich.edu) and **David Speyer**. *DeRham cohomology of cluster algebras*. Preliminary report.

I will talk about work in progress where we are trying to compute the algebraic deRham cohomology of cluster algebras. The main application we have in mind is to the calculation of the cohomology of open Richardson varieties (likely to be cluster varieties), which can be identified with the Ext-spaces of Verma modules of a complex simple Lie algebra. (Received February 01, 2013)

1089-13-115 **Kyungyong Lee** (klee@math.wayne.edu) and **Ralf Schiffler*** (schiffler@math.uconn.edu). *Positivity for cluster algebras*.

The positivity conjecture states that for every cluster variable the coefficients in the Laurent expansion with respect to any cluster are positive. In this talk, we will discuss some of the progress made towards proving this conjecture. (Received February 07, 2013)

1089-13-123 **Greg Muller*** (gmuller@lsu.edu), Mathematics Department, LSU, Baton Rouge, LA 70803, and **Jenna Rajchgot** (jenna.rajchgot@gmail.com) and **Karen E Smith** (kesmith@umich.edu). *F-regularity and cluster algebras*. Preliminary report.

This talk will consider reductions of cluster algebras to fields of odd characteristic. Algebras in positive characteristic have a Frobenius endomorphism, which sends every element to its p -th power. We show that the Frobenius map on an upper cluster algebra admits a standard splitting; that is, a left inverse. When the cluster algebra is locally acyclic, this Frobenius splitting is regular; that is, it does not fix any non-trivial ideals. This has geometric consequences for locally acyclic cluster algebras over \mathbb{Z} ; in particular, they have at worst rational singularities. (Received February 08, 2013)

1089-13-184 **Andrei Zelevinsky*** (andrei@neu.edu), Department of Mathematics, Northeastern University, 360 Huntington Avenue, Boston, MA 02115. *Positivity and tameness in rank 2 cluster algebras*. Preliminary report.

In a joint work in progress with Kyungyong Lee and Li Li, we study the relationship between the positivity property in rank 2 cluster algebras, and the property of such an algebra to be tame. More precisely, we show that a rank 2 cluster algebra has a basis of indecomposable positive elements if and only if it is of finite or affine type. This statement seems to disprove one of the conjectures by Fock and Goncharov.

The talk will be totally elementary, does not assume any preliminary knowledge of cluster algebras, and should be accessible to graduate students. (Received February 14, 2013)

1089-13-208 **Ilke Canakci*** (ilke.canakci@uconn.edu), 196 Auditorium Road, Unit 3009, Storrs, CT 06269-3009, and **Ralf Schiffler** (ralf.schiffler@uconn.edu), 196 Auditorium Road, Unit 3009, Storrs, CT 06269-3009. *On surface cluster algebras: Snake and band graph calculus.*

Recall from [MSW] that there is a combinatorial formula for the Laurent expansion of cluster variables for cluster algebras arising from surfaces [FST] given by perfect matchings of snake graphs associated to arcs in the surface. I will report on a joint work with Ralf Schiffler in which we introduce the notion of abstract snake graphs and develop a graphical calculus for surface cluster algebras. Moreover, I will talk about how to extend this results to abstract band graphs.

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[MSW] G. Musiker, R. Schiffler and L. Williams, Positivity for cluster algebras from surfaces, *Adv. Math.* **227**, (2011), 2241–2308.

(Received February 19, 2013)

1089-13-236 **Tai Huy Ha***, 6823 St. Charles Avenue, New Orleans, LA 70118, and **Russ Woodroffe**. *Regularity of squarefree monomial ideals and vertex decomposable complexes.*

We shall discuss a general bound for the regularity of squarefree monomial ideals based on invariants of associated combinatorial objects. We shall also discuss an algorithm to compute the regularity when the corresponding simplicial complex is vertex decomposable. (Received February 16, 2013)

1089-13-240 **Tomoki Nakanishi** and **Salvatore Stella*** (stella.sa@husky.neu.edu), 360 Huntington ave, 567 Lake Hall, Boston, MA 02115. *Wonder of sine-Gordon Y-systems.*

The sine-Gordon Y-systems and the reduced sine-Gordon Y-systems were introduced by Tateo in the 90's in the study of the integrable deformation of conformal field theory by the thermodynamic Bethe ansatz method. The periodicity property and the dilogarithm identities concerning these Y-systems were conjectured by Tateo, and recently proved using cluster algebras. In this talk we explain how these Y-systems can be understood using triangulations of polygons and how this provide automatically a proof of both periodicity and dilogarithm identities in full generality. (Received February 16, 2013)

1089-13-272 **Bruce Olberding*** (olberdin@nmsu.edu), Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88003-8001. *Integrally closed rings and the Zariski-Riemann space of valuation rings.* Preliminary report.

Let F be a field, and let D be a subring of F . The Zariski-Riemann space \mathfrak{X} of F/D consists of the valuation rings that contain D and have quotient field F . Zariski introduced a topology on \mathfrak{X} under which \mathfrak{X} is a spectral space. Moreover, \mathfrak{X} can be viewed as a locally ringed space in a natural way. We discuss some applications of this point of view to the structure of subrings of F that are integrally closed in F . (Received February 18, 2013)

1089-13-291 **Nathan Reading*** (nathan_reading@ncsu.edu). *Mutation-linear algebra and universal geometric coefficients for cluster algebras.*

I will discuss the “mutation-linear algebra” associated to matrix mutation and in particular the notion of a “basis for B ,” where B is an exchange matrix. (A basis for B should not be confused with an additive basis for the associated cluster algebra.) The initial motivation for this work is to understand universal geometric cluster algebras. I will consider the case where B is the signed adjacency matrix of a triangulation of a marked surface. In this case, the question of finding a basis amounts to a subtle property of the surface that I call the Null Tangle Property. (Received February 18, 2013)

1089-13-301 **Warren W McGovern*** (warren.mcgovern@fau.edu), Jupiter, FL 33458. *Rings of Continuous Functions of Countable Range.* Preliminary report.

We will discuss the types of rings discussed in the title and mention what is known about such rings. We will try to give many examples and to point out some interesting and/or difficult problems in the area. (Received February 18, 2013)

1089-13-351 **David Speyer** and **Hugh Thomas*** (hthomas@unb.ca). *c-vectors of acyclic cluster algebras.*

c -vectors are part of the combinatorial framework of a cluster algebra. Though relative late-comers in cluster algebra theory, they play a powerful role: it was shown by Nakanishi and Zelevinsky that many facts about cluster algebras follow by an elementary argument once it is known that each c -vector has all entries either

non-negative or non-positive. I will give a classification of the collections of vectors that can appear as the c -vectors of a cluster in a skew-symmetrizable cluster algebra starting from an acyclic seed, in terms of the root system associated to the initial seed. This talk is based on arXiv:1203.0277. (Received February 19, 2013)

14 ► Algebraic geometry

1089-14-3 **Brendan E Hassett*** (hassett@rice.edu), Rice University, Department of Mathematics, MS 136, 6100 S. Main Street, Houston, TX 77251-1892. *Rational curves on symplectic varieties.*

A rational curve is the image of the projective line under a non-constant morphism to an algebraic variety. The simplest examples of symplectic varieties are K3 surfaces, i.e., simply-connected algebraic surfaces with a holomorphic symplectic form. Rational curves on K3 surfaces are studied in a wide range of fields, from arithmetic geometry to mathematical physics. While there are beautiful formulas for the number of such curves (of a fixed degree, counted with suitable multiplicities), it remains open in general whether every K3 surface contains infinitely many. For symplectic varieties in higher dimensions, rational curves govern birational geometry. New ideas from moduli theory and derived categories are transforming our understanding of their structure. (Received February 18, 2013)

1089-14-14 **James S Wolper***, Department of Mathematics, Idaho State University, 921 S. 8th Ave., MS8085, Pocatello, ID 83209-8085. *Estimating the Genus of a Complex Affine Curve using Computational Topology.*

Persistent homology is used to attempt to estimate the genus of a complex algebraic curve represented by a point cloud constructed from an affine piece. Examples of point clouds on space curves depend on an amusing exercise in elementary algebraic geometry. Experimental results include affine plane and space curves. (Received November 14, 2012)

1089-14-26 **Daniel Litt*** (dalitt@stanford.edu). *Motivic Analytic Number Theory.*

There are beautiful and unexpected connections between algebraic topology, number theory, and algebraic geometry, arising from the study of the configuration space of (not necessarily distinct) points on a variety. In particular, there is a relationship between the Dold-Thom theorem, the analytic class number formula, and the "motivic stabilization of symmetric powers" conjecture of Ravi Vakil and Melanie Matchett Wood. I'll discuss several ideas and open conjectures surrounding these connections, and describe the proof of one of these conjectures—a Hodge-theoretic obstruction to the stabilization of symmetric powers—in the case of curves and algebraic surfaces. Everything in the talk will be defined from scratch, and should be quite accessible. (Received January 08, 2013)

1089-14-31 **Zhiyuan li*** (zli2@stanford.edu), 450 Serra Mall, Bldg 380, Stanford, CA 94305. *Picard groups on moduli spaces of K3 surfaces.*

In this talk, I will give a brief introduction to the Noether-Lefschetz divisors on the moduli space of quasi-polarized K3 surfaces. It is conjectured that the Picard groups on these moduli spaces are spanned by the Noether-Lefschetz divisors. We verify this conjecture in the case of low degree K3 surfaces. (Received January 15, 2013)

1089-14-64 **Cory Scott*** (cory.scott@coloradocollege.edu), **Liljana Babinkostova**, **Kevin Bombadier**, **Matthew Cole** and **Thomas Morrell**. *Elliptic Reciprocity.*

An elliptic curve over a finite field \mathbb{F} is the set of solutions $(x, y) \in \mathbb{F}$ to a cubic equation $y^2 = x^3 + ax + b$. Of particular interest are elliptic curves over a finite field. Elliptic curve fields of prime order are useful in a variety of cryptographic applications. We first define and investigate the properties of elliptic pairs, elliptic lists, and elliptic cycles over a square-free positive integer d . Silver and Stange address similar concepts called amicable pairs and aliquot cycles. We show that for $d = 3$ that there exists an elliptic cycle of length six. We prove some further results about elliptic lists where we derive an upper bound on the length of a list as a function of d . (Received January 28, 2013)

1089-14-75 **Nero Budur*** (nbudur@nd.edu). *Cohomology jump loci of local systems.*

Cohomology jump loci of smooth complex quasi-projective varieties have a rigid arithmetic structure. This is a joint result with Botong Wang. We will also present a conjectural interpretation of cohomology support loci via Bernstein-Sato ideals which would immediately provide implemented algorithms to compute these loci. This

interpretation is a generalization of the classical result of Malgrange and Kashiwara relating Milnor monodromy of hypersurfaces with classical Bernstein-Sato polynomials. (Received February 01, 2013)

1089-14-76 **Brian Lehmann***, MS-136, P.O. Box 1892, Houston, TX 77251. *Big cycles and volume functions*. Preliminary report.

The volume of a divisor is an important invariant measuring the "positivity" of its numerical class. I will discuss an analogous construction for cycles of arbitrary codimension. In particular, this construction yields geometric characterizations of big cycle classes modeled on the well-known criteria for divisor and curve classes. (Received February 01, 2013)

1089-14-81 **Nora Ganter** and **Arun Ram*** (aram@unimelb.edu.au), Department of Mathematics and Statistics, University of Melbourne, Parkville, VIC, Victoria 3010, Australia. *Generalized Schubert Calculus*.

We show how to study the generalized cohomology (cobordism) of flag varieties using two models, the Borel model and the moment graph model. We study the differences between the Schubert classes and the Bott-Samelson classes. We will illustrate the results by showing some rank 2 computations which generalize various earlier computations of Griffeth-Ram (in equivariant K-theory) and of Calmes-Petrov-Zainoulline (in non-equivariant cobordism). (Received February 02, 2013)

1089-14-98 **Clint McCrory*** (clint@math.uga.edu), Mathematics Department, University of Georgia, Athens, GA 30602. *Products and the real weight filtration*.

A decade ago Burt Totaro introduced a functorial weight filtration of the cohomology of a real algebraic variety, in analogy with Deligne's weight filtration for a complex variety. The properties of this filtration and the dual filtration of homology have been developed by Parusiński and the author. Here we present current work of Thierry Limoges, who has shown that the cross product, cup product, and cap product are compatible with the weight filtration. These products are defined at the chain level, in the derived category of filtered chain complexes. The geometry of singularities of semialgebraic chains and Nash constructible functions plays a crucial role in the definition of these filtered products. (Received February 05, 2013)

1089-14-119 **David M Zureick-Brown*** (dzb@mathcs.emory.edu), 628 West College Ave., Decatur, GA 30030. *Families of abelian varieties with big monodromy*.

I will discuss various recent results about explicit families of abelian varieties with big monodromy. (Received February 08, 2013)

1089-14-124 **Mateusz Michalek** (wajcha2@poczta.onet.pl), **Luke Oeding*** (oeding@math.berkeley.edu) and **Piotr Zwiernik** (pzwiernik@berkeley.edu). *Secant Cumulants*.

We study the secant line variety of the Segre product of projective spaces using special cumulant coordinates adapted for secant varieties. We show that the secant variety is covered by open normal toric varieties. We prove that in cumulant coordinates its ideal is generated by binomial quadrics. We present new results on the local structure of the secant variety. In particular, we show that it has rational singularities and we give a description of the singular locus. We also classify all secant varieties that are Gorenstein. Moreover, generalizing (Sturmfels and Zwiernik 2012), we obtain analogous results for the tangential variety. (Received February 08, 2013)

1089-14-149 **Simon CF Rose*** (simon@mast.queensu.ca), Department of Math Stats, Jeffery Hall University Ave, Kingston, Ontario K7L3N6, Canada. *Reduced Gromov-Witten theories and the crepant resolution conjecture*. Preliminary report.

It is known that the Gromov-Witten invariants of any surface with $h^{2,0} > 0$ must be trivial, as any curve class can be deformed so as to be non-algebraic. We will provide an overview of the different constructions of reduced virtual fundamental classes that exist in the literature, as well as go over the relationship between the crepant resolution conjecture and its reduced version. (Received February 11, 2013)

1089-14-152 **Letao Zhang*** (lz7@rice.edu), Math Dept, Rice Univ, 6100 Main ST, Houston, TX 77005. *Character Formulas on Cohomology of Deformations of Hilbert Schemes of K3 Surfaces*.

Let X be a Kaehler deformation of the Hilbert scheme of n points on a $K3$ surface. We compute the graded character formula of the generic Mumford-Tate group representation on the cohomology ring of X . Also, we derive a generating series for deducing the number of canonical Hodge classes of degree $2n$. (Received February 11, 2013)

1089-14-155 **Renzo Cavalieri***, 905 smith street, Fort Collins, CO 80524. *Polynomiality and Wall Crossings in Hurwitz Theory.*

in this talk I will present a story that began with the observation of Goulden-Jackson-Vakil that families (of simple and double) Hurwitz numbers tend to have interesting polynomiality or piecewise-polynomiality aspects. Cavalieri-Johnson-Markwig subsequently exploited the combinatorics suggested by tropical geometry in order to gain a good understanding of this phenomena, and to be able to describe wall crossings. The story is now evolving with an attempt of lifting these observations from the level of "numbers" to the level of "cycles". Again, the parallel with tropical geometry helps shed light on the combinatorial features of certain families of Hurwitz classes. The story is understood so far in genus 0 and becomes substantially more complicated in higher genus. The most recent work discussed is joint work with Aaron Bertram and Hannah Markwig. (Received February 11, 2013)

1089-14-181 **Anatoly Libgober*** (libgober@uic.edu), Dept. of Mathematics. Univ. of Illinois, at Chicago. 851 S.Morgan Str., Chicago, IL 60607. *Twisted Alexander polynomials of algebraic curves.* Preliminary report.

Alexander polynomials, twisted by unitary representations of the fundamental group, first appeared in the context of the fundamental groups of links and later were considered in the case of the fundamental groups of the complements to plane algebraic curves. I will describe extensions of several geometric and topological properties of ordinary Alexander polynomials of plane curves to twisted case. (Received February 13, 2013)

1089-14-213 **Noah Giansiracusa*** (noahgian@math.berkeley.edu). *The moduli space of stable rational curves—one \mathbb{G}_a away from toric.*

I'll discuss joint work with Brent Doran (ETH) in which we construct an "algebraic uniformization" of the moduli space $\bar{M}_{0,n}$ of stable, rational n -pointed curves: we present it as a non-reductive GIT quotient of affine space by a non-linearizable action of a solvable group. This is accomplished by replacing the universal torsor with an \mathbb{A}^1 -homotopic model that encodes the global projective geometry of the moduli space in a more accessible way. We show in particular that the Cox ring of $\bar{M}_{0,n}$ is a \mathbb{G}_a -invariant subring of a polynomial ring, which allows it to be computed for any fixed n , in principle, by standard invariant theory algorithms, and which shows a precise sense in which $\bar{M}_{0,n}$ is "one \mathbb{G}_a away" from being a toric variety. (Received February 15, 2013)

1089-14-217 **Grigoriy Blekherman** and **Gregory G. Smith*** (ggsmith@mast.queensu.ca), Department of Mathematics & Statistics, Jeffery Hall, Queen's University, Kingston, Ontario K7L3N6, Canada, and **Mauricio Velasco**. *Nonnegative sections and sums of squares.* Preliminary report.

A polynomial with real coefficients is nonnegative if it takes on only nonnegative values. For example, any sum of squares is obviously nonnegative. For a homogeneous polynomial with respect to the standard grading, Hilbert famously characterized when the converse statement hold, i.e. when every nonnegative homogeneous polynomial is a sum of squares. In this talk, we will examine this converse for homogenous polynomials with respect to a positive multigrading (or more generally global sections of a line bundle). In particular, we will provide many new examples in which every nonnegative homogeneous polynomial is a sum of squares. (Received February 15, 2013)

1089-14-219 **Andrea Brini**, **Renzo Cavalieri** and **Dustin Ross*** (ross@math.colostate.edu), 233 Weber Building, Colorado State University, Fort Collins, CO 80523. *The Open String McKay Correspondence for Type A Singularities.*

A longstanding conjecture of Ruan states that the Gromov-Witten (GW) theory of a Gorenstein orbifold should be equivalent to the GW theory of a crepant resolution of the coarse space. In 2008, Coates-Corti-Iritani-Tseng proved Ruan's crepant resolution conjecture (CRC) for A_n singularities by equating the big quantum cohomologies. We extend this correspondence to open GW invariants of the orbi-threefold $[\mathbb{C} \times A_n]$ and its resolution.

In particular, following a proposal of Iritani, we first show that the quantum D-modules associated to the orbifold and its resolution are local neighborhoods in a global quantum D-module. Unique to our methods is the fact that our global quantum D-module is defined completely in terms of A-model coordinates. By analytically continuing flat sections, we give an explicit isomorphism of the local quantum D-modules associated to the spaces and we show that this arises from a natural identification of K-groups, thereby verifying a conjecture of Iritani. The explicit computation of the isomorphism allows us to state and prove an open CRC where we interpret the open GW invariants as sections of Givental space and show that these sections are identified after an appropriate linear transformation. (Received February 15, 2013)

1089-14-222 **William Graham*** (wag@math.uga.edu) and **Victor Kreiman**. *Excited Young diagrams, equivariant K -theory, and Schubert varieties.*

We give combinatorial descriptions of the restrictions to T -fixed points of the classes of structure sheaves of Schubert varieties in the T -equivariant K -theory of Grassmannians and of maximal isotropic Grassmannians of orthogonal and symplectic types. We also give formulas, based on these descriptions, for the Hilbert series and Hilbert polynomials at T -fixed points of the corresponding Schubert varieties. These descriptions and formulas are given in terms of two equivalent combinatorial models: excited Young diagrams and set-valued tableaux. In types A_n and C_n the restriction formulas had been proved earlier by Kreiman by a different method. In type A_n , the formula for the Hilbert series had been proved earlier by Li and Yong. The method of this paper, which relies on a restriction formula of Graham and Willems, is based on the method used by Ikeda and Naruse to obtain the analogous formulas in equivariant cohomology. We also give Hilbert series and Hilbert polynomial formulas which are valid for Schubert varieties in any cominuscule flag variety, in terms of the 0-Hecke algebra. (Received February 15, 2013)

1089-14-248 **Bryden Cais***, The University of Arizona, Department of Mathematics, 617 N. Santa Rita Ave., Tucson, AZ 85721. *A lower bound for the a -number of a wildly ramified p -cover.* Preliminary report.

Given a branched $\mathbf{Z}/p\mathbf{Z}$ -cover of curves $\pi : Y \rightarrow X$ in characteristic p , we establish a lower bound on the a -number of Y in terms of the ramification data of π which is nontrivial whenever π exhibits sufficiently wild ramification. (Received February 17, 2013)

1089-14-249 **Brian Harbourne*** (bharbourne1@unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588. *Conjectural Containments and Counterexamples.*

I will discuss recent work regarding conjectures and counterexamples involving containment of symbolic powers of ideals in ordinary powers. (Received February 17, 2013)

1089-14-258 **Greg Blekherman*** (greg@math.gatech.edu), **Greg Smith** and **Mauricio Velasco**. *A Tale of Three Theorems.*

I will explain and draw connections between the following three theorems: (1) Classification of varieties of minimal degree by Del Pezzo and Bertini, (2) Hilbert's theorem on nonnegative polynomials and sums of squares (3) Classification of lattice polytopes of degree 1 by Batyrev and Nill (Joint work with Greg Smith and Mauricio Velasco) (Received February 17, 2013)

1089-14-293 **Markus Reineke*** (reineke@math.uni-wuppertal.de), Fachbereich C - Mathematik, Bergische Universitaet Wuppertal, D - 42097 Wuppertal, Germany. *Quiver Grassmannians.*

Quiver Grassmannians are projective varieties parametrizing compatible configurations of subspaces of vector spaces. We will derive their basic geometric properties and review their relation to representation theory and to categorification. We will discuss universality, single out a class of "well-behaved" quiver Grassmannians, and construct desingularizations. (Received February 18, 2013)

1089-14-297 **Alexander R Duncan*** (arduncan@umich.edu). *Equivariant Rational Maps and Unirationality.*

Let G be a finite group. Given two varieties with faithful G -actions, I consider the question of whether there exist equivariant rational maps between them. For rational surfaces and *birational* maps, the question has been well-studied and is related to determining the conjugacy classes of subgroups of the plane Cremona group. We discuss examples of rational G -surfaces X and Y which are not equivariantly birational but for which there exist equivariant dominant rational maps both from X to Y and from Y to X .

Of particular interest will be the class of G -unirational varieties. We say that a variety X with a faithful G -action is G -unirational if there exists a linear representation V and a G -equivariant dominant rational map $V \dashrightarrow X$. When $G = 1$, this corresponds to the usual notion of unirationality. We will outline connections between G -unirational varieties and arithmetic questions regarding ordinary unirationality and the existence of points. (Received February 18, 2013)

1089-14-303 **Dan Bates**, Fort Collins, CO, **Brent Davis**, Fort Collins, CO, **David Eklund**, Fort Collins, CO, **Eric Hanson*** (hanson@math.colostate.edu), Fort Collins, CO, and **Chris Peterson**, Fort Collins, CO. *Perturbed Regeneration homotopies for finding all isolated solutions to a polynomial system.*

Homotopy continuation methods provide a way to approximate solutions to polynomial systems. Regeneration is a recent development that uses a linear product decomposition to create a series of homotopies which approximate

the nonsingular isolated solutions of a polynomial system. This series of homotopies is in many cases more computationally efficient than other existing homotopy methods, however isolated singular solutions might not be found. We provide a hybrid technique, Perturbed Regeneration, that takes advantage of the efficiency of Regeneration homotopies for finding nonsingular isolated solutions of general systems, but still allows for the approximation of singular isolated solutions. (Received February 18, 2013)

1089-14-322 **Hirotschi Abo, David Eklund and Chris Peterson*** (peterston@math.colostate.edu). *Eigenschemes and deformations in the tangent bundle.*

An eigenscheme is a scheme that encodes information about the generalized eigenspaces of a matrix. Eigenschemes can be realized as zero-loci of sections of the tangent bundle to projective space. This talk will discuss eigenschemes, their construction via the tangent bundle, and applications of such a construction. (Received February 18, 2013)

1089-14-323 **Morgan Veljko Brown*** (morganvb@umich.edu). *t-structures for the Derived McKay Correspondence.*

Let $G \subset SL_n(\mathbb{C})$ be a finite group. When $n = 2$, the McKay correspondence relates the representation theory of G with the geometry of the minimal resolution of \mathbb{C}^n/G . This minimal resolution is given by a certain moduli space of G -equivariant subschemes called G -Hilb. Bridgeland, King, and Reid realized this correspondence as an equivalence of derived categories between G equivariant sheaves on \mathbb{C}^n and sheaves on G -Hilb and extended it to dimension 3. In general, one expects for two birational varieties X and X' that their derived categories are related according to the differences in the canonical divisors K_X and $K'_{X'}$.

We will explore the possibility of realizing the category of sheaves on G -Hilb via combinatorial data. This is joint work with Ian Shipman. (Received February 18, 2013)

1089-14-333 **Susan Margulies*** (margulies@math.psu.edu), **Jesus De Loera, Jon Lee and Shmuel Onn.** *Hilbert's Nullstellensatz and Linear Algebra: An Algorithm for Determining Combinatorial Infeasibility.*

Unlike systems of linear equations, systems of multivariate polynomial equations over the complex numbers or finite fields can be compactly used to model combinatorial problems. In this way, a problem is feasible (e.g. a graph is 3-colorable, Hamiltonian, etc.) if and only if a given system of polynomial equations has a solution. Via Hilbert's Nullstellensatz, we generate a sequence of large-scale, sparse linear algebra computations from these non-linear models to describe an algorithm for solving the underlying combinatorial problem. As a byproduct of this algorithm, we produce algebraic certificates of the non-existence of a solution (i.e., non-3-colorability, non-Hamiltonicity, or non-existence of an independent set of size k).

In this talk, we present theoretical and experimental results on the size of these sequences, and the complexity of the Hilbert's Nullstellensatz algebraic certificates. For non-3-colorability over a finite field, we utilize this method to successfully solve graph problem instances having thousands of nodes and tens of thousands of edges. We also describe methods of optimizing this method, such as finding alternative forms of the Nullstellensatz, adding carefully-constructed polynomials to the system, branching and exploiting symmetry. (Received February 18, 2013)

1089-14-344 **Daniel Schulteis*** (dschulteis@math.arizona.edu). *Virtual invariants on Quot schemes over Del Pezzo surfaces.*

Let C be a smooth projective curve and consider $\text{Quot}_C(\mathbb{G}(r, N), d)$, the Quot scheme of degree d , rank $N-r$ quotients of \mathcal{O}_C^N . Numerous mathematicians have studied the intersection theory of $\text{Quot}_C(\mathbb{G}(r, N), d)$, culminating in a proof that the virtual count of maps from C to the Grassmannian $\mathbb{G}(r, N)$ satisfies the Vafa-Intriligator formula. We will explore the history of this problem and focus on recent generalizations when C is replaced by a Del Pezzo surface. (Received February 18, 2013)

1089-14-353 **Renzo Cavalieri, Steffen Marcus*** (marcus@math.utah.edu) and **Jonathan Wise.** *Computations and comparisons for double ramification classes on the moduli space of curves.*

In this talk I will discuss the two main approaches for constructing double ramification classes. We will see how the two approaches compare and how this comparison relates to other results in Hurwitz theory. This is joint and continuing work with Renzo Cavalieri and Jonathan Wise. (Received February 19, 2013)

1089-14-359 **Anna S. Bertiger*** (annab@math.cornell.edu), NY. *The Action of Sp_n on $Flags(\mathbb{C}^n)$.* Preliminary report.

I will present the seemingly geometric problem of understanding the orbits of the action of the symplectic group on the flag manifold and a very combinatorial plan of attack for studying this problem. Along the way we will meet such combinatorial objects as involutions, permutations matrix Schubert varieties, and pipedreams and also investigate unions of matrix Schubert varieties. I intend for this talk to be friendly with all of the appropriate notions defined. (Received February 19, 2013)

1089-14-361 **Mathias Lederer and Jenna Rajchgot*** (rajchgot@umich.edu). *“Doubly universal” Gröbner bases.*

A universal Gröbner basis of an ideal in a polynomial ring is a finite set of polynomials which is a (non-reduced, non-minimal) Gröbner basis for every monomial order. In this talk, I’ll explain a way to generalize this notion from ideals in a polynomial ring to an ideal sheaf defining the universal family over a Hilbert scheme, and I’ll explicitly describe the form of such a universal Gröbner basis. I’ll end by discussing an application which should serve as motivation for the construction. (Received February 19, 2013)

1089-14-378 **Chayapa Darayon*** (darayon2@illinois.edu). *Arithmetically Gorenstein and Gorenstein Richardson Varieties in the Grassmannian.* Preliminary report.

Combinatorial criteria for when a Schubert variety in the Grassmannian is Gorenstein and when it is arithmetically Gorenstein have been discovered and are equivalent. Here we study a Richardson variety which is defined to be the intersection of a Schubert variety and an opposite Schubert variety. We present combinatorial characterizations for which Richardson varieties in the Grassmannian are Gorenstein and arithmetically Gorenstein. The two criteria are not equivalent unlike the Schubert variety case. (Received February 19, 2013)

1089-14-382 **Atoshi Chowdhury*** (atoshi@berkeley.edu). *Stability of line bundles on reducible surfaces.*

Our motivating problem is to construct a modular compactification of the universal Picard stack (the moduli space of line bundles) over the moduli space of smooth surfaces of general type. We focus on extending the universal Picard stack to a moduli space parametrizing line bundles on certain surfaces which may be reducible. To ensure the separatedness of this extension, we impose on the line bundles parametrized a stability condition which is related to GIT-stability and generalizes the notion of balanced multidegree for line bundles on reducible curves. I’ll discuss some properties of this stability condition and of the resulting moduli spaces of stable line bundles. (Received February 19, 2013)

1089-14-386 **Gonzalez Villa Manuel*** (villa@mathi.uni-heidelberg.de), Im Neuenheimer Feld 288, 69120 Heidelberg, Germany. *Inner jumping numbers of non-degenerate polynomials.*

The inner jumping numbers were introduced by Budur to relate two different measures of the complexity of the singularities of an effective divisor D on a nonsingular complex variety X : the jumping numbers of a pair (X, D) and the Hodge spectrum at a singular point of D . We give an elementary proof for an effective and combinatorial description of inner jumping numbers (< 1) of non-degenerate polynomials. We illustrate the results with a few concrete examples. (Received February 19, 2013)

1089-14-387 **Mahir B. Can, Michael Joyce and Benjamin J. Wyser*** (bwyser@illinois.edu), 250 Altgeld Hall, 1409 W. Green St., Urbana, IL 61801. *Factoring sums of Schubert polynomials.* Preliminary report.

To the unique closed orbit of $H = Sp(2n, \mathbb{C})$ or $H = O(n, \mathbb{C})$ on the type A flag variety, there is a subset of Weyl group elements (the “ W -set” of the orbit) having the property that the class of the orbit closure in $H^*(G/B)$ is equal to the sum of the Schubert classes corresponding to elements of the W -set. These W -set elements have been computed explicitly in recent work of Can-Joyce. When combined with recent work of the presenter, which uses equivariant localization and the self-intersection formula to give a formula for this cohomology class, one obtains a non-trivial factorization of the corresponding sum of Schubert polynomials. We will discuss this result, as well as some recent generalizations of it to the closed orbits of other spherical subgroups on the flag variety. These other spherical subgroups correspond to other G -orbits on the wonderful compactification of the symmetric space G/H . (Received February 19, 2013)

1089-14-400 **Julianna Tymoczko*** (jtymoczko@smith.edu), Department of Mathematics and Statistics, 44 College Lane, Northampton, MA 01063. *Weyl group representations on a family of subvarieties of flag varieties.*

GKM theory is a topological machine to describe the cohomology of appropriate varieties using algebraic combinatorics. We will sketch the relevant topological background. We will then show how GKM theory can be used to describe representations of the Weyl group on flag varieties and on subvarieties of the flag variety called Hessenberg varieties. We will end with recent work of Teff and its implications for these representations. (Received February 19, 2013)

1089-14-404 **Benjamin J. Wyser*** (bwyser@illinois.edu), 250 Altgeld Hall, 1409 W. Green St., Urbana, IL 61801. *K-orbits on the flag variety as universal degeneracy loci for flagged vector bundles splitting as direct sums.*

The geometry of the closures of orbits of a symmetric subgroup on the flag manifold of a complex reductive group G play an important role in the infinite-dimensional representation theory of an associated real form of G . Such orbit closures can be thought of as generalizations of Schubert varieties, and most questions one has about Schubert varieties can equally well be posed about these more general orbit closures. I will discuss the question of giving formulas for the torus-equivariant fundamental classes of such orbit closures. The approach uses equivariant localization and the self-intersection formula applied to the closed orbits, and divided difference operators to compute the remaining formulas. These formulas can be interpreted as Chern class formulas for the fundamental classes of certain types of degeneracy loci. In this talk, I will focus on a family of examples which are associated to degeneracy loci defined for a vector bundle over a base variety which is equipped with a complete flag of subbundles, and which splits as a direct sum of two subbundles. This includes one case in type A , as well as all cases in types BCD . (Received February 20, 2013)

15 ► *Linear and multilinear algebra; matrix theory*

1089-15-42 **Peter G. Casazza*** (casazzap@missouri.edu), Department of Mathematics, Columbia, MO 65211. *Fusion Frames for Wireless Sensor Networks.*

We look at a series of recent papers which involve applications of fusion frames to wireless sensor networks for threat detection. (Received January 17, 2013)

1089-15-398 **Kouros Modarresi*** (kouros@m@alumni.stanford.edu). *Using an Iterative Singular Value Decomposition Algorithm for Collaborative Filtering Problems.*

Modern data set consists of very large number of rows (experiments or users) and each row has large number of columns (features). This high dimensional property of modern data introduces many challenges in the fields involving “data analysis”. Apart from the difficulties related to storage problems, algorithmic inefficiencies, and lack of effective visualization techniques, the major concern is that the normal statistical and machine learning algorithms may not be used for high dimensional data. This phenomenon of high dimensional data that causes the above difficulties is called “The Curse of Dimensionality”. In this work - in addressing the curse of dimensionality - we approximate the data matrix using low rank approximation method. This method assumes that the main information in the data lies in a low dimensional space that has far lower dimensions than that of nominal space suggested by the appearance of the data. To achieve this approximation, we use a “Iterative Singular Value Decomposition” algorithm. This algorithm converges very fast and leads to higher accuracy in computing missing/unknown entries of data matrices, and thus is a desirable algorithm for collaborative filtering problem. (Received February 19, 2013)

16 ► *Associative rings and algebras*

1089-16-10 **Sergio Lopez-Permouth, Jeremy Moore and Steve Szabo*** (steve.szabo@eku.edu), Eastern Kentucky University, Department of Mathematics and Statistics, 521 Lancaster Avenue, Richmond, OH 40475. *Algebras Having Bases Consisting Entirely of Units.*

We introduce a hierarchy of notions about algebras having a basis \mathcal{B} consisting entirely of units. Such a basis is called an invertible basis and algebras that have invertible bases are said to be invertible algebras. The other conditions considered in the said hierarchy include the requirement that for an invertible basis \mathcal{B} , the set of inverses \mathcal{B}^{-1} be itself a basis, the notion that \mathcal{B} be closed under inverses and the idea that \mathcal{B} be closed under

products. It is shown that the last property is unique of group rings. Many examples are considered and it is determined that the hierarchy is for the most part strict. For any field $F \neq F_2$, all semisimple F -algebras are invertible. Semisimple invertible F_2 -algebras are fully characterized. Connections between invertible algebras and S-rings (rings generated by units) are also explored. (Received February 14, 2013)

1089-16-25 **Kulumani M Rangaswamy*** (ranga@uccs.edu), Department of Mathematics, University of Colorado at Colorado Springs, Colorado Springs, CO 80918. *Leavitt path algebras with prescribed Krull dimension.*

Let E be an arbitrary directed graph and let K be any field. Necessary and sufficient conditions are given on the graph E in order that the Leavitt path algebra L of the graph E over the field K has Krull dimension 0. Leavitt path algebras of various prescribed Krull dimension are investigated. Height one prime ideals of L are described. (Received January 05, 2013)

1089-16-40 **Ashish K Srivastava*** (asrivast3@slu.edu), Department of Mathematics & CS, Saint Louis University, Saint Louis, MO 63103, and **Pedro A Guil Asensio.**
Automorphism-invariant modules and additive unit representations in endomorphism rings.

A module is called automorphism-invariant if it is invariant under any automorphism of its injective hull. Dickson and Fuller have shown that if R is a finite-dimensional algebra over a field \mathbb{F} with more than two elements then an indecomposable automorphism-invariant right R -module must be quasi-injective. We extend and simplify the proof of this result by showing that any automorphism-invariant module over an algebra over a field with more than two elements is quasi-injective. Our proof is based on the study of the additive unit structure of endomorphism rings. (Received January 16, 2013)

1089-16-50 **T.Y. Lam** and **Pace P. Nielsen*** (pace@math.byu.edu), Department of Mathematics, Brigham Young University, Provo, UT 84602. *Jacobson's Lemma, Drazin Inverses, and Strongly Clean Rings.*

If a ring element $\alpha = 1 - ab$ is Drazin invertible, so is $\beta = 1 - ba$. There is a simple formula for the Drazin inverse. We derive a new proof of this fact, which generalizes to many more cases. For example, we show that $1 - ab$ is strongly clean if and only if $1 - ba$ is also strongly clean. Examples are provided showing connections to commuting idempotents. (Received January 22, 2013)

1089-16-68 **Lia Vas*** (l.vas@uscience.edu), Dept. of Mathematics, Physics and Statistics, University of the Sciences, 600 S. 43rd St., Philadelphia, PA 19104. *Rings with Dimension.*

The existence of a well-behaved dimension of a finite von Neumann algebra has led to the study of such a dimension of some finite Baer *-rings. We study the assumptions on a ring that guarantee the existence of a well-behaved dimension and prove the existence of such a dimension for a class of semihereditary involutive rings. This class is wider than the class of finite Baer *-rings with dimension considered in the past: it includes some rings that are not Rickart *-rings. (Received January 29, 2013)

1089-16-70 **Gene Abrams*** (abrams@math.uccs.edu), University of Colorado, Colorado Springs, CO 80918, and **Muge Kanuni** (muge.kanuni@boun.edu.tr), Boğaziçi University, 34342 Istanbul, Turkey. *Tensor products of algebras taken from various classes of quotients of path algebras.* Preliminary report.

For a directed graph E , we denote by \widehat{E} the doubled graph of E , obtained by adding an edge e^* corresponding to each edge e of E , but with opposite direction. For a graph E and field K , the *Cohn path algebra of E with coefficients in K* is the path algebra $K\widehat{E}$, modulo the so-called (CK1) relations: $e^*e = r(e)$ for each edge e of E (where $r(e)$ denotes the range vertex of e), and $f^*e = 0$ for each edge $f \neq e$. (So, for example, the Leavitt path algebra $L_K(E)$ can naturally be viewed as a quotient of $C_K(E)$.) In this talk we describe tensor products of algebras taken from various classes of quotients of path algebras. In particular, we present some partial results and observations regarding the tensor product of two Cohn path algebras. (Received January 30, 2013)

1089-16-91 **Lucas David-Roesler*** (roesler.lucas@gmail.com), 101 N. College Avenue, Annville, PA 17003. *The AG-invariant for $(m+2)$ -angulations.*

In 2012 Juan Carlos Bustamante and Viviana Gubitosi used Hochschild cohomology to classify all finite dimensional algebras which are derived equivalent to m -cluster tilted algebras of type A . In their analysis they also consider an invariant introduced by Avella-Alaminos and Geiss but they do not directly use this invariant because Hochschild cohomology is easier to compute. We will show a method to calculate the invariant of Avella-Alaminos and Geiss when the algebra is constructed from an $(m+2)$ -angulation of a surface with marked points

in the boundary. When the surface is a disc these algebras are m -cluster tilted algebras. (Received February 04, 2013)

1089-16-151 **Miodrag C Iovanov*** (yovanov@gmail.com). *Frobenius-Artin Algebras and Infinite Linear Codes.*

We show that Frobenius rings that are at the same time Artin algebras have characterizations that extend and unify well known results of Nakayama for algebras over fields, and some recent results for finite Frobenius rings [T.Honold, Arch. Math (Basel) 76, no. 6 (2001)], and which entitles one to call such algebras Frobenius-Artin algebras. On the other hand, finite Frobenius rings have raised interest due to connections with coding theory [J.A.Wood, Proc. AMS 136, no. 2 (2008)]. It has been recently shown that they are characterized as rings for which linear codes have the extension property [J.A.Wood, Amer. J. Math 121, no.3 (1999)]. We generalize this to arbitrary rings, and show that in the infinite case, the categorical properties of Frobenius rings are captured by this extension property. Namely, we show that a ring has the extension property for linear codes if and only if it is the product of a finite Frobenius ring and a quasi-Frobenius ring with no finite representations (modules). We give two proofs of this, one that uses measure theory and compact groups, and another combinatorial one. (Received February 11, 2013)

1089-16-157 **Muge Kanuni*** (muge.kanuni@boun.edu.tr), Bogazici University, Department of Mathematics, 34342 Istanbul, Turkey, and **Atabey Kaygun** (atabey.kaygun@bahcesehir.edu.tr), Bahcesehir University, Department of Mathematics, Istanbul, Turkey. *Global dimensions of some artinian algebras.*

In this article we obtain lower and upper bounds for global dimensions of a class of artinian algebras in terms of global dimensions of a finite subset of their artinian subalgebras. Finding these bounds for the global dimension of an artinian algebra A is realized via an explicit algorithm we develop. This algorithm is based on a directed graph (not the Auslander-Reiten quiver) we construct, and it allows us to decide whether an artinian algebra has finite global dimension in good number of cases. (Received February 19, 2013)

1089-16-162 **Stephen Doty*** (doty@math.luc.edu), Loyola University Chicago, Mathematics and Statistics, Chicago, IL 60660. *Rational Schur algebras and their q -analogues.*

The rational Schur algebras $S_k(n; r, s)$ determine the rational representations of a general linear group $GL_n(k)$ over an infinite field k in bi-degree (r, s) . When $s = 0$ they coincide with the classical Schur algebras $S_k(n, r)$ studied in J.A. Green's Springer Lecture Notes 830. There is a double centralizer theorem with respect to mixed tensor space $T^{r,s} := (k^n)^{\otimes r} \otimes ((k^n)^*)^{\otimes s}$ in which Schur–Weyl duality holds between the commuting actions of the group $GL_n(k)$ and the walled Brauer algebra $\mathfrak{B}_{r,s}(n)$ — introduced by Benkart et al in J. Algebra 1994 — with parameter specialized to n ; hence we have

$$S_k(n; r, s) = \text{End}_{\mathfrak{B}_{r,s}(n)}(T^{r,s}).$$

This algebra (for any k, r, s, n) is a generalized Schur algebra in the sense of S. Donkin, and thus is quasihereditary. The entire picture admits ‘quantization’ as worked out in recent preprints by the speaker in joint work with R. Dipper and F. Stoll. (Received February 12, 2013)

1089-16-247 **Ben Webster*** (b.webster@neu.edu), 360 Huntington Avenue, Boston, MA 02115. *Representation theory of symplectic singularities.*

Since they were introduced about 2 decades ago, symplectic singularities have shown themselves to be a remarkable branch of algebraic geometry. They are much nicer in many ways than arbitrary singularities, but still have a lot of interesting nooks and crannies.

I’ll talk about these varieties from a representation theorist’s perspective. This might sound like a strange direction, but remember, any interesting symplectic structure is likely to be the classical limit of an equally interesting non-commutative structure, whose representation theory we can study. While this field is still in its infancy, it includes a lot of well-known examples like universal enveloping algebras and Cherednik algebras, and has led a lot of interesting places, including to categorified knot invariants and a conjectured duality between pairs of symplectic singularities. I’ll give a taste of these results and try to indicate some interesting future directions. (Received February 17, 2013)

1089-16-270 **Peng Shan*** (pengshan@mit.edu). *Categorifications and rational Cherednik algebras.*

Varagnolo and Vasserot conjectured an equivalence of categories between the category \mathcal{O} of cyclotomic rational Cherednik algebras and an affine parabolic category \mathcal{O} . This conjecture implies character formulae for simple modules of these Cherednik algebras and the Koszulity of its category \mathcal{O} . I will explain a proof of this conjecture. This is a joint work with R. Rouquier, M. Varagnolo and E. Vasserot. (Received February 17, 2013)

1089-16-296 **K. R. Goodearl**, Department of Mathematics, University of California, Santa Barbara, CA 93106, and **M. T. Yakimov***, Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Quantum cluster algebra structures on quantum nilpotent algebras.*

We will describe a result that proves the existence of quantum cluster algebra structures on a very general axiomatically defined class of quantum nilpotent algebras. This has a wide range of applications, among which are a proof of the Berenstein-Zelevinsky conjecture for quantum double Bruhat cells, construction of quantum cluster algebra structures on quantum unipotent groups in full generality, and others. (Received February 18, 2013)

1089-16-314 **Christopher Holston*** (ch327505@ohio.edu), **Sergio R. Lopez-Permouth** (lopez@ohio.edu), **Joseph Mastromatteo** (jm424809@ohio.edu) and **Jose E. Simental-Rodriguez** (simentalrodriguez.j@husky.neu.edu). *An Alternative Perspective to Projectivity.*

We approach the analysis of the extent of the projectivity of modules from a fresh perspective as we introduce the notion of relative subprojectivity. A module M is said to be N -subprojective if for every epimorphism $g : B \rightarrow N$ and homomorphism $f : M \rightarrow N$, there exists a homomorphism $h : M \rightarrow B$ such that $gh = f$. For a module M , the *subprojectivity domain* of M is defined to be the collection of all modules N such that M is N -subprojective. Modules whose subprojectivity domain is smallest as possible will be called *subprojectively poor* (*sp-poor*) or *projectively indigent* (*p-indigent*). While we do not know if *sp-poor* modules exist over every ring, their existence is determined for various families. For example, we determine that artinian serial rings have *sp-poor* modules. This work is a natural continuation to recent papers that have embraced the systematic study of the injectivity, projectivity and subinjectivity domains of rings. (This is a joint work with Sergio R. López-Permouth, Joseph Mastromatteo and José E. Simental-Rodríguez). (Received February 18, 2013)

1089-16-318 **Alexander J Diesl*** (adiesl@wellesley.edu), Wellesley College, 106 Central Street, Wellesley, MA 02481, and **Thomas J Dorsey**, **Wolf Iberkleid**, **Ramiro LaFuente-Rodriguez** and **Warren Wm. McGovern**. *Strongly Clean Triangular Matrix Rings.*

A ring is called strongly clean if every element can be written as the sum of a unit and an idempotent which commute. We consider the problem of determining when a triangular matrix ring over an abelian clean ring is strongly clean. This problem has been considered by many authors, but the vast majority of the results that have been obtained so far apply to the special case of a triangular matrix ring over a local ring. Using a variety of topological ideas (specifically, the Zariski topology and the theory of Pierce sheaves), we provide conditions on an abelian ring which imply that any triangular matrix over it is strongly clean. (Received February 18, 2013)

1089-16-337 **Gordana Glisa Todorov*** (g.todorov@neu.edu), 360 Huntington Av., Boston, MA 02115, and **Kiyoshi Igusa** (igusa@brandeis.edu), South Street, Waltham, MA. *Clusters in Continuous Cluster Categories*. Preliminary report.

Continuous cluster categories were introduced as a generalization of the original cluster categories. In the continuous cluster categories the clusters may have infinite collections of objects, and we will describe them and their mutations. Joint work with Kiyoshi Igusa, Brandeis University (Received February 18, 2013)

1089-16-345 **Alexander J. Diesl** and **Thomas J. Dorsey*** (dorsey@ccrwest.org). *Rings of maximal clean index.*

Lee and Zhou introduced the notion of clean index of a ring or element thereof. Specifically, for $x \in R$, the clean index of x is the cardinality of the set of idempotents e for which $x - e$ is a unit, and the clean index of R is the supremum of the clean indices of the elements of R . Along these lines, we will say that $x \in R$ is maximally clean if $x - e$ is a unit for each idempotent e of R , and that R is maximally clean if it has a maximally clean element. We will examine the class of maximally clean rings and variants thereof, and we will examine the clean index of certain rings. (Received February 18, 2013)

1089-16-348 **Gangyong Lee** and **Cosmin Roman*** (cosmin@math.osu.edu), The Ohio State University, Lima, Galvin Hall, 4240 Campus Dr, Lima, OH 45804, and **Xiaoxiang Zhang**. *Rings with faithful modules whose endomorphism rings are division rings.*

Primitive rings, introduced in 1945 by Jacobson, are a mainstay in Ring Theory. Their structure, and their properties makes their class a very useful one in various fields, from ring and modules theory, through representation theory to topology. Recently, we defined a natural generalization of primitive rings, in line with a direction of research that puts emphasis not only on properties of modules, but also on relationship between the

modules and their endomorphism rings. A right (left) rudimentary ring is a ring which admits a faithful right (left) R -module whose endomorphisms ring is a division ring. A number of properties will be presented, among other distinguishing this new class from the class of right primitive rings. Methods of producing some of these rings will be given, as well as a number of examples. Connections to prior work will also be shown, e.g. with research in the so-called Converse Schur Lemma problem. (Joint work with G. Lee and X. Zhang.) (Received February 18, 2013)

17 ► *Nonassociative rings and algebras*

1089-17-41 **Young-Jo Kwak*** (kwaky@colorado.edu), Hyogo, Japan. *Orthogonal groups $O(n)$ over $GF(2)$ as automorphisms.*

We show that $O(n) = \text{Aut}(o(n))$ by the arguments based on the combinatorial algebra. (Received February 16, 2013)

1089-17-207 **Eric Sommers*** (esommers@math.umass.edu), U of Massachusetts, Amherst, and the NSF. *On q -analogues of the characteristic polynomials of some hyperplane arrangements.*

We will discuss a singly-graded version of the (rational) parking function modules for a Weyl group W . By way of Springer theory, these representations have a decomposition where each summand is indexed by an irreducible representation of W . One output from this decomposition is a q -analogue of the characteristic polynomial attached to each restricted hyperplane arrangement associated to W .

These q -characteristic polynomials control some of the combinatorics of objects that are counted by the rational Catalan numbers of W (for example, non-crossing partitions). We plan to describe this connection, which is joint work with Vic Reiner. (Received February 15, 2013)

1089-17-292 **Gregory P. Wene*** (gpwene2011@hotmail.com), The University of Texas at San Antonio, Department of Mathematics, One UTSA Circle, San Antonio, TX 78249-0624. *Permutations of Cubical Arrays.*

The structure constants of an n -dimensional algebra A over a field F determine an n -by- n -hy- n cube called the cubical array associated with the algebra A . Knuth permuted the indices of the cubical associated with a finite semifields to generate new geometries. We no longer require that the algebras be finite and ask "Is it possible to choose a basis for the algebra such any permutation of the indices of the structure constants leaves the algebra unchanged?" What are the associated algebras? We show that the property weakly quadratic is invariant under all permutations of the indices of the corresponding cubical array. We present two algebras for which the cubical array is invariant under all permutations of the indices. (Received February 18, 2013)

1089-17-340 **Martina Lanini*** (martina.lanini@unimelb.edu.au). *The stable moment graph and periodic structures in the affine category O .*

We associate with any affine Kac-Moody algebra \mathfrak{g} its stable moment graph. Such a graph turns out to be the main tool in order to get a categorical version of a result by Lusztig, stating certain stability property for affine Kazhdan-Lusztig polynomials. This stabilisation phenomenon bridges the Hecke algebra to its periodic module, which -according to the Feigin-Frenkel conjecture- governs the representation theory of \mathfrak{g} at a critical level. The stable moment graph is expected to enable us to apply moment graph techniques to the study of critical level representations (joint with P. Fiebig). (Received February 18, 2013)

18 ► *Category theory; homological algebra*

1089-18-158 **Kiyoshi Igusa*** (igusa@brandeis.edu) and **Gordana G Todorov**. *Infinite group actions on Frobenius cyclic posets.* Preliminary report.

A cyclic poset is a generalization of a cyclically ordered set. Linearizations of these categories are Frobenius categories in the special case when the cyclic poset is Frobenius. In our previous paper we considered finite group actions on Frobenius cyclic posets and produced continuous cluster categories of type D as examples. In this paper we extend this construction to infinite groups and, as examples, we construct the well-known cluster tubes and certain cluster categories of surface type. The advantage of this construction is that it gives an elementary description of all of the objects in the triangulated category and also explains the tagged arcs as being part of the idempotent completion construction. (Received February 12, 2013)

- 1089-18-307 **Amber Russell*** (arusell@math.uga.edu) and **Laura Rider**. *Cuspidal Local Systems and a Decomposition Involving Perverse Sheaves on the Nilpotent Cone*. Preliminary report.

In a recent paper, Achar uses hyperbolic localization to give an orthogonal decomposition of the category of constructible sheaves on the nilpotent cone. In particular, he decomposes this category into those arising from the Springer sheaf and those not. In this talk, I will discuss the ongoing project to refine this decomposition using central character properties and Lusztig's cuspidal local systems. (Received February 18, 2013)

19 ► *K*-theory

- 1089-19-87 **Guoliang Yu*** (guoliangyu@math.tamu.edu), Department of Mathematics, College Station, TX 77843. *The algebraic K-theory Novikov conjecture and higher index theory*.

In this talk, I will give an introduction to the algebraic K-theory Novikov conjecture and discuss its connection to higher index theory. (Received February 03, 2013)

- 1089-19-112 **Rufus Willett*** (rufus@math.hawaii.edu), Mathematics Department, University of Hawaii at Manoa, 2565 McCarthy Mall, Honolulu, HI 96822. *New approaches to localization algebras*.

Localization algebras are C^* -algebras introduced by Guoliang Yu in the mid-nineties, inspired by the heat kernel approach to (local) index theory. Their K-theory gives a model for K-homology that is particularly useful for attacking Baum-Connes-type conjectures, among other things. In this talk, I'll discuss some recent refinements and generalizations.

This is joint work with Guoliang Yu. (Received February 07, 2013)

- 1089-19-234 **Mariusz Wodzicki***, Department of Mathematics, University of California, Berkeley, Berkeley, CA 94720-3840. *Algebraic and Hermitian K-theory of stable algebras*.

I will describe Bott periodicity phenomena in algebraic and Hermitian K-theory of stable algebras. This is a joint work with Max Karoubi. (Received February 16, 2013)

20 ► *Group theory and generalizations*

- 1089-20-167 **Gizem Karaali*** (gizem.karaali@pomona.edu), Pomona College Mathematics Department, 610 North College Avenue, Claremont, CA 91711. *Supercharacters and exponential sums*.

The theory of supercharacters, recently developed by Andre and Diaconis-Isaacs, can be used to derive the fundamental algebraic properties of a variety of classes of exponential sums of interest in number theory. In this talk we will describe a general framework; specific examples will relate to Ramanujan, Kloosterman and Gauss sums. (Received February 12, 2013)

- 1089-20-170 **Eric Marberg*** (emarberg@math.mit.edu). *Combinatorics of the unipotent characters of a finite Coxeter system*.

To each finite, irreducible Coxeter system (W, S) , Lusztig has associated a set of "unipotent characters" $\text{Uch}(W)$. When (W, S) is crystallographic, $\text{Uch}(W)$ arises from Lusztig's set of unipotent representations of a corresponding finite reductive group, though for non-crystallographic Coxeter groups the definition of $\text{Uch}(W)$ is heuristic. By construction, $\text{Uch}(W)$ always contains as a subset the set $\text{Irr}(W)$ of complex irreducible characters of W . However, we typically view the elements $\text{Uch}(W)$ not as characters but simply as formal objects with a few defining attributes. In this short talk I will give Lusztig's definition of the set $\text{Uch}(W)$ for each finite Coxeter system, and review the combinatorial indexing sets for these objects which generalize the better known sets of partitions and bipartitions labeling the irreducible characters of the classical Weyl groups. As motivation for why one should care (more) about these things, I'll outline a surprising way in which several different types of heuristic data attached to $\text{Uch}(W)$ interact to describe the irreducible multiplicities of a natural W -representation. (Received February 13, 2013)

1089-20-179 **Jason Fulman** (fulman@usc.edu), Department of Mathematics, University of Southern California, Los Angeles, CA 90089, and **C. Ryan Vinroot*** (vinroot@math.wm.edu), Department of Mathematics, College of William and Mary, P. O. Box 8795, Williamsburg, VA 23187. *Generating functions for real character degree sums of finite general linear and unitary groups.*

It is known that if χ is any real-valued irreducible complex character of $GL(n, q)$, then χ is the character of a real representation, that is, the Frobenius-Schur indicator of χ is 1. It follows that the sum of the degrees of these real-valued characters of $GL(n, q)$ is equal to the number of elements in the group which square to the identity, which we can count. On the other hand, we may use symmetric functions to obtain a generating function for the degree sum for real-valued characters. In the case that q is even, we use q -series identities to obtain a new proof that all real-valued characters of $GL(n, q)$ have indicator 1. When q is odd, we instead apply this known result to obtain what seems to be a new q -series identity.

In the case of the finite unitary group $U(n, q)$, the Frobenius-Schur indicators of its characters in general are unknown. We compute a generating function for the sum of the real character degrees for this group, again using symmetric function theory, and also by applying the results for $GL(n, q)$ and a change of variables $q \mapsto -q$. In the end, we obtain a generating function for the sum of the degrees of real-valued characters of $U(n, q)$ which have indicator 1, and one for the sum of those with indicator -1 . (Received February 13, 2013)

1089-20-188 **S. Garibaldi*** (skip@mathcs.emory.edu), Department of Math & CS, 400 Dowman Dr, Atlanta, GA 30322, and **V. Petrov** and **N. Semenov**. *Applications of Chow motives to algebraic groups.*

When studying Galois cohomology of semisimple algebraic groups, one often wants to know the fibers of some cohomological invariant. One well-known solution to this kind of problem is Merkurjev's Theorem saying that every quadratic form in I^2 with trivial Clifford invariant actually belongs to I^3 . We describe analogous results for exceptional groups, all proved using Chow motives but with no motives appearing in the statements. (Received February 14, 2013)

1089-20-237 **Christopher Bowman**, **Maud De Visscher** and **Rosa Orellana*** (rosa.c.orellana@dartmouth.edu), Department of Mathematics, 6188 Kemeny Hall, Hanover, NH 03755. *The partition algebra and the Kronecker coefficients.*

We re-interpret the Kronecker problem in the setting of the partition algebra using the Schur-Weyl duality between the symmetric group and the partition algebra. This re-interpretation has allowed us to explain the existing results on the Kronecker coefficients such as the limiting phenomena, the bounds for stability and the passage between the Kronecker and reduced Kronecker coefficients in the Grothendieck group of the partition algebra. In addition, we obtain a formula for the reduced Kronecker coefficients which has allowed us to give simple formulas for special cases of the Kronecker coefficients. (Received February 16, 2013)

1089-20-238 **Stephen Doty** (doty@math.luc.edu) and **Aaron Lauve*** (lauve@math.luc.edu), Loyola University Chicago (LUC), and **George Seelinger, III** (gseelinger@luc.edu). *Permutation modules for Brauer algebras.* Preliminary report.

In 2005, Hartmann and Paget introduced a notion of permutation modules, Specht modules, and Young modules for Brauer algebras (via induction from their symmetric group analogs). More recently, Doty proposed an alternative definition of permutation modules (as decomposition of tensor space). We compare and contrast the two definitions, and also look for Specht and Young modules in this new model. This is joint work with S. Doty and G Seelinger, III. (Received February 16, 2013)

1089-20-244 **Kevin W Bombardier*** (kwbombardier@wichita.edu), **L. Babinkostova**, **M. Cole**, **T. Morrell** and **C. Scott**. *Algebraic Properties of Generalized Rijndael-like Ciphers.*

We provide conditions under which the set of Rijndael-like functions considered as permutations of the state space and based on operations of the finite field $\text{GF}(p^k)$ ($p \geq 2$) is not closed under functional composition. These conditions justify using a sequential multiple encryption to strengthen the Advanced Encryption Standard (AES), a Rijndael cipher with specific block sizes. We provide conditions under which the group generated by the Rijndael-like round functions based on operations of the finite field $\text{GF}(p^k)$ ($p \geq 2$) is equal to the symmetric group or the alternating group on the state space. (Received February 17, 2013)

1089-20-246 **Pramod N Achar*** (pramod@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803-4918, and **Anthony Henderson, Daniel Juteau** and **Simon Riche**. *Weyl group actions on the Springer sheaf*.

The *Springer sheaf* is the perverse sheaf on the nilpotent cone of a reductive group that arises as the push-forward of the constant sheaf along the Springer resolution. Classical Springer theory is concerned with the study of this perverse sheaf with coefficients in \mathbb{C} or $\overline{\mathbb{Q}}_\ell$. In 2007, Juteau initiated the study of *modular* Springer theory. In this work, we study Springer theory with coefficients in an arbitrary noetherian ring of finite global dimension. In particular, I will discuss the relationship between two constructions of the Weyl group action, generalizing a result that is well known in the ℓ -adic case. (Received February 17, 2013)

1089-20-256 **George J McNinch*** (mcninchg@member.ams.org), Department of Math, Tufts University, 503 Boston Ave, Medford, MA 02155. *The existence and descent of Levi factors*.

Let G be a linear algebraic group over a field k , and suppose that the geometric unipotent radical R of G is defined over k . A Levi factor of G is a reductive k -subgroup M of G which is a complement to R . When the characteristic of k is positive, G may fail to have a Levi factor. In this talk, we report on results concerning Levi factors.

For a field extension L of k , suppose that the group G/L obtained by base-change has a Levi factor ("defined over L "). When G is connected, it doesn't seem to be known whether G must have a Levi factor ("defined over k "), even when L is a separable (or Galois) extension of k . In this talk, we describe some conditions which guarantee that G will have a Levi factor.

Finally, suppose that k is perfect and that G is the special fiber of a parahoric group scheme associated with a connected reductive group H over a local field K . Some previous work of the speaker showed that G has a Levi factor whenever H splits over an unramified extension of K . Following a suggestion of G. Prasad, we show in some recent work that G/L has a Levi factor where L is an algebraic closure of the residue field k , provided that H splits over a tamely ramified extension of K . (Received February 17, 2013)

1089-20-261 **Tom Halverson*** (halverson@macalester.edu), Macalester College, Saint Paul, MN 55105, and **Georgia Benkart**. *McKay Centralizer Algebras I*. Preliminary report.

For a finite subgroup G of the special unitary group SU_2 , we study the centralizer algebra $Z_k(G) = \mathbf{End}_G(V^{\otimes k})$ of G acting on the k -fold tensor product of its defining 2-dimensional representation V . These subgroups can be classified using the simply laced affine Dynkin diagrams of type A,D,E, and the McKay correspondence relates the representation theory of these groups to the associated Dynkin diagram. We use this connection to show that the structure and representation theory of $Z_k(G)$ as a semisimple matrix algebra is controlled by the combinatorics of the corresponding Dynkin diagram. (Received February 17, 2013)

1089-20-273 **Carl Mautner*** (cmautner@math.harvard.edu). *A geometric Ringel duality for nilpotent cones*.

Given a connected complex reductive group and any field k , one can define the equivariant derived category of sheaves of k -vector spaces on the associated nilpotent cone. In joint work with Pramod Achar, we define an interesting autoequivalence of this category using Fourier transform. I will discuss the definition of this functor, how it behaves on simple perverse sheaves when $\text{char } k = 0$ and how, for $\text{char } k > 0$, it is related to the algebraic notion of Ringel duality. Time (and progress) permitting, I will touch on joint work with Tom Braden, in which we study a similar duality for hypertoric varieties. (Received February 18, 2013)

1089-20-288 **Daniel C. Cohen*** (cohen@math.lsu.edu) and **Henry K. Schenck**. *Chen ranks of arrangement groups*.

The Chen groups of a group G are the lower central series quotients of the maximal metabelian quotient of G . In the case where G is an arrangement group, the fundamental group of the complement of a complex hyperplane arrangement, we relate the ranks of the Chen groups to the first resonance variety, a jump locus for the cohomology of G . (Received February 18, 2013)

1089-20-375 **Ivan Mirkovic*** (mirkovic@mathg.umass.edu). *Loop Grassmannians*. Preliminary report. This is a presentation of a joint work with Allen Knutson and Joel Kamnitzer and with Simon Riche. (Received February 19, 2013)

1089-20-408 **Jerzy Kocik*** (jkocik@math.siu.edu), Department of Mathematics, Mail Code 4408, Southern Illinois University, Carbondale, IL 62901. *Topology of the Apollonian disk packing and physics.*

Certain topological and group-theoretic aspects of an Apollonian disk packing will be juxtaposed with the physics of spin and geometry of space-time. (Received February 20, 2013)

1089-20-410 **Christopher Dodd*** (cdodd@math.utoronto.ca), Department of Mathematics, University of Toronto, 40 St. George St., Room 6290, Toronto, Ontario M5S 2E4, Canada. *Modules over Algebraic Quantizations and representation theory.* Preliminary report.

Recently, there has been a great deal of interest in the theory of modules over algebraic quantizations of so-called symplectic resolutions. In this talk I'll discuss some new work -joint, and very much in progress- that opens the door to giving a geometric description to certain categories of such modules; generalizing classical theorems of Kashiwara and Bernstein in the case of D-modules on an algebraic variety. (Received February 20, 2013)

22 ► Topological groups, Lie groups

1089-22-4 **Raphael Rouquier*** (rouquier@math.ucla.edu). *Higher Representation Theory.*

Classical representation theory studies symmetries of sets and vector spaces, whereas higher representation theory studies symmetries of categories and higher structures. There is a class of such higher symmetries encoded by simple Lie algebras, which can be viewed as the next step after quantization. We will discuss algebraic, geometrical and topological aspects and applications. (Received February 20, 2013)

1089-22-63 **Galyna Dobrovol'ska*** (galdobr@gmail.com), 5837 S Blackstone Ave, Chicago, IL 60637-1855. *Fourier-Deligne transform and representations of the symmetric group.*

We calculate the Fourier-Deligne transform of the IC extension to \mathbb{C}^{n+1} of the local system \mathcal{L}_Λ on the cone over $Conf_n(\mathbb{P}^1)$ associated to a representation Λ of S_n , where the length $n - k$ of the first row of the Young diagram of Λ is at least $\frac{|\Lambda| - 1}{2}$. The answer is the IC extension to the dual vector space \mathbb{C}^{n+1} of the local system \mathcal{R}_λ on the cone over the k -th secant variety of the rational normal curve in \mathbb{P}^n , where \mathcal{R}_λ corresponds to the representation λ of S_k , the Young diagram of which is obtained from the Young diagram of Λ by deleting its first row. We also prove an analogous statement for S_n -local systems on fibers of the Abel-Jacobi map. We use our result on the Fourier-Deligne transform to rederive a part of a result of Michel Brion on Kronecker coefficients. The talk is based on <http://arxiv.org/abs/1301.2157> (Received January 27, 2013)

1089-22-125 **Mark Reeder*** (reederma@bc.edu). *On the Geometric Invariant Theory of Moy-Prasad filtrations.*

A reductive p -adic group G is like an ocean. At each point x on the surface of the ocean, the depths of G are layered by Moy-Prasad filtrations of the parahoric subgroup at x . The graded version of the filtration at x turns out to be identical to the grading on the Lie algebra of G (reduced modulo p) whose Kac coordinates are given by x . The GIT of such gradings was described by Vinberg over \mathbb{C} , and extended to base fields of characteristic $p > 0$ by Levy. When applied to p -adic groups, this connection between Moy-Prasad and Vinberg-Levy theories gives new constructions of supercuspidal representations of G arising from stable vectors in the epipelagic zone at x , and solves the fundamental problem of classifying nondegenerate K -types in Moy-Prasad theory. This is joint work with Jiu-Kang Yu. (Received February 08, 2013)

1089-22-212 **Martha E Precup*** (mprecup@nd.edu). *An Affine Paving of Hessenberg Varieties.*

Hessenberg varieties are closed subvarieties of the full flag variety. Examples of Hessenberg varieties include both Springer fibers and the flag variety. In this talk we will discuss methods used to study these varieties, many of which are derived from methods used to study Springer fibers. We show that Hessenberg varieties corresponding to nilpotent elements which are regular in a Levi factor are paved by affines. We then provide a partial reduction from paving Hessenberg varieties for arbitrary elements to paving those corresponding to nilpotent elements, generalizing results of Tymoczko. (Received February 15, 2013)

1089-22-252 **Sam Evens*** (sevens@nd.edu), Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556. *Eigenvalue coincidences and K -orbits on the flag variety.*

This talk is based on joint work with Mark Colarusso which relates the Gelfand-Zeitlin integrable system to orbits of $K = GL(n-1) \times GL(1)$ on the flag variety of C^n . For $x \in gl(n)$, let x_{n-1} be its upper left hand $n-1$ by $n-1$ corner. We consider the variety $X_k \in gl(n)$ consisting of matrices x with the property that x and x_{n-1}

share at least $n - 1$ generalized eigenvalues, counting multiplicity. We show that X_k is a union of irreducible components coming from K -orbits on the flag variety of length $n - k - 1$. (Received February 17, 2013)

1089-22-266 **Peter E Trapa*** (ptrapa@math.utah.edu), Department of Mathematics, University of Utah, Salt Lake City, UT 84112-0090. *Applications of Lusztig-Vogan Polynomials.*

In the setting of a symmetric subgroup acting on a flag variety, Lusztig and Vogan have recently introduced a new family of polynomials which compute traces of certain involutions on relevant local intersection homology groups. (When the involution is trivial, the trace is the dimension, and the new polynomials reduce to the classical Kazhdan-Lusztig-Vogan polynomials.) I will explain applications of the new polynomials to the study of unitary representations of reductive Lie groups (part of joint work with Adams, van Leeuwen, and Vogan). (Received February 17, 2013)

1089-22-267 **Peter E Trapa*** (ptrapa@math.utah.edu), Department of Mathematics, University of Utah, Salt Lake City, UT 84112-0090. *Signatures of invariant forms on Harish-Chandra modules.*

I will explain a few of the key ideas behind the computation of the unitary dual of a reductive Lie group given in a recent preprint with Adams, van Leeuwen, and Vogan. Some of these ideas have inspired geometric counterparts in the setting of equivariant mixed Hodge modules on the flag variety. (Received February 17, 2013)

1089-22-285 **Igor Rivin*** (rivin@temple.edu), Mathematics Department, 1805 N Broad St, Philadelphia, PA 19122. *Random elements in interesting groups.* Preliminary report.

I describe the question (and some partial answers) to finding uniform random elements in lattices in interesting Lie groups. (Received February 18, 2013)

1089-22-311 **Laura Rider*** (lrider1@math.lsu.edu) and **Pramod N. Achar.** *Parity sheaves on the affine Grassmannian and coherent sheaves on the nilpotent cone.* Preliminary report.

Arkhipov, Bezrukavnikov, and Ginzburg proved a derived equivalence relating constructible sheaves on the affine Grassmannian for an algebraic group G and coherent sheaves on the nilpotent cone for the Langlands dual group. I will speak about this relationship in the modular setting. In particular, I will discuss the key role played by the theory of parity sheaves as developed by Juteau, Mautner, and Williamson. (Received February 18, 2013)

28 ► *Measure and integration*

1089-28-85 **Tushar Das***, Oregon State University, Department of Mathematics, Corvallis, OR 97331. *Geometrically extremal measures.*

A major direction within the field of metric Diophantine approximation on manifolds has been to study the class of extremal measures. In the case of Euclidean spaces, these are finite Borel measures which do not charge the set of very well approximable points (VWA). In the early '00s Dmitry Kleinbock, Elon Lindenstrauss and Barak Weiss introduced a geometric condition on a measure they named friendliness and showed that it implied extremality. Friendly measures are those which are Federer and nonplanar and which satisfy a certain decay condition. It turns out that many interesting measures do not satisfy Kleinbock, Lindenstrauss and Weiss's condition but are nevertheless extremal. We study a new geometric condition which implies extremality, but is more flexible than friendliness. We present some of our results about this class. This work is part of an ongoing joint collaboration with Lior Fishman (North Texas), David Simmons (Ohio State) and Mariusz Urbański (North Texas). (Received February 02, 2013)

30 ► *Functions of a complex variable*

1089-30-394 **Kouros Tavakoli*** (ktavakoli@okcu.edu). *Relationship between generalized Kobayashi metric and hyperbolic metric.*

In this talk, I will present some interesting examples to study the relationship between the generalized Kobayashi metric and the hyperbolic metric. The geometric and analytic properties will be discussed. (Received February 19, 2013)

32 ► *Several complex variables and analytic spaces*

1089-32-53 **Howard Masur*** (masur@math.uchicago.edu), **Jon Chaika** and **Yitwah Cheung**.
Schmidt games for billiards, interval exchange transformations and measured foliations.

We consider the related concepts of sets of bounded directions for billiard flows in rational polygons, sets of bounded interval exchanges, and sets of bounded measured foliations. These generalize the notion of real numbers having bounded continued fractions expansions. We show that the sets we consider are all winning sets for Schmidt games and their various generalizations by McMullen. This is joint work with Jon Chaika and Yitwah Cheung (Received February 18, 2013)

1089-32-69 **David B. Massey*** (d.massey@neu.edu). *The Swing and the Structure of the Vanishing Cycles of Non-isolated Hypersurface Singularities.*

Together with Lê, I proved a result which put a new upper-bound on the rank of the lowest-degree non-trivial cohomology group of the Milnor fiber of a non-isolated affine hypersurface singularity. In this talk, I will describe a generalization of this result to the stalk cohomology of the vanishing cycles of intersection cohomology complexes in all degrees. Even in the case of the constant sheaf on affine space, this yields new general bounds on the cohomology of the Milnor fiber with integral coefficients. (Received January 29, 2013)

1089-32-100 **Xavier Gomez-Mont*** (gmont@cimat.mx), CIMAT, AP 402, 36240 Guanajuato, Gto., Mexico. *Signatures on the Primitive Parts of the Real Jacobian Algebra.* Preliminary report.

Given a real analytic function germ $f : \mathbb{R}^n \rightarrow \mathbb{R}$ with an absolutely isolated singularity, one can associate to it its real Milnor Algebra

$$\mathcal{A} := \frac{\mathcal{A}_{\mathbb{R}^n, 0}}{\left(\frac{\partial f}{\partial x_1}, \dots, \frac{\partial f}{\partial x_n}\right)}$$

which is a finite dimensional real vector space. One may define on it a real valued non-degenerate bilinear form defined by multiplication in the algebra and then applying Grothendieck residue. Arnold has shown that the signature of this bilinear form contains the information of the Euler characteristics of the real Milnor fibres. One can further decompose \mathcal{A} with its bilinear form using the map of multiplication by $f : \mathcal{A} \rightarrow \mathcal{A}$ to obtain non-degenerate bilinear forms on the primitive parts of \mathcal{A} , and hence primitive signatures. The research we are undertaking is concentrated around giving a topological interpretation of the signatures in the primitive parts of \mathcal{A} . We will present some results that relate these primitive signatures to indices of vector fields tangent to the real Milnor fibres and how these indices change when one passes through the singularity. (Received February 05, 2013)

1089-32-131 **Graham Denham** and **Alexander I. Suciu*** (a.suciu@neu.edu), Department of Mathematics, Northeastern University, Boston, MA 02115. *Multinets, parallel connections, and Milnor fibrations of arrangements.*

The characteristic varieties of a space are the jump loci for homology with coefficients in rank 1 local systems. The way in which the geometry of these varieties may vary with the characteristic of the ground field is reflected in the homology of finite cyclic covers. We exploit this phenomenon to detect torsion in the homology of Milnor fibers of projective hypersurfaces. One tool we use is the interpretation of the degree 1 characteristic varieties of a hyperplane arrangement complement in terms of orbifold fibrations and multinets on the corresponding matroid. Another tool is a polarization construction, based on the parallel connection operad for matroids. Our main result gives a combinatorial machine for producing arrangements whose Milnor fibers have torsion in integral homology. In particular, this shows that Milnor fibers of hyperplane arrangements do not necessarily have a minimal cell structure. (Received February 09, 2013)

35 ► *Partial differential equations*

1089-35-48 **Long Lee, Gregory Lyng*** (glyng@uwyo.edu) and **Irena Vankova**. *The Gaussian Semiclassical Soliton Ensemble.*

We describe a number of careful numerical experiments motivated by the semiclassical (zero-dispersion) limit of the focusing nonlinear Schroedinger equation. These experiments were designed to study the evolution of a particular family of perturbations of the initial data. These asymptotically small perturbations are precisely those that result from modifying the initial data by use of formal approximations to the spectrum of the associated spectral problem; such modified data has always been a standard part of the analysis of zero-dispersion limits

of integrable systems. However, in the context of the focusing nonlinear Schroedinger equation, the ellipticity of the Whitham equations casts some doubt on the validity of this procedure. Remarkably, our experiments show that the rate of convergence of the modified data to the true data is propagated to positive times including times after wave breaking. (Received January 22, 2013)

1089-35-52 **C Li*** (congmingli@gmail.com) and **Y Lei**. *Existence/nonexistence criteria for some systems of elliptic type.*

We provide the dichotomy criteria on the existence and nonexistence of positive solutions for some nonlinear partial differential and integral systems of elliptic systems. These necessary and sufficient conditions provide some insightful understanding of the related systems and they are also interesting in their own. (Received January 23, 2013)

1089-35-72 **Dhanapati Adhikari*** (dadhikari@marywood.edu), Marywood University, 2300 Adams Avenue, Scranton, PA 18509. *The 2D incompressible Boussinesq equation with vertical dissipation.*

One major issue concerning the Boussinesq equations is whether or not their classical solutions are always global in time. This talk presents the global existence and uniqueness of solutions of the 2D incompressible Boussinesq equation with only vertical dissipation. (Received January 31, 2013)

1089-35-83 **Jiahong Wu*** (jiahong@math.okstate.edu), Department of Mathematics, Oklahoma State University, Stillwater, OK 74078. *The 2D Boussinesq equations with partial or fractional dissipation.*

The Boussinesq equations concerned here model geophysical flows such as atmospheric fronts and ocean circulations. Mathematically the 2D Boussinesq equations serve as a lower-dimensional model of the 3D hydrodynamics equations. In fact, the 2D Boussinesq equations retain some key features of the 3D Euler and the Navier-Stokes equations such as the vortex stretching mechanism. The global regularity problem on the 2D Boussinesq equations with partial or fractional dissipation has attracted considerable attention in the last few years. This talk reviews recent results on various cases of partial dissipation and presents most recent developments on the 2D Boussinesq equations with fractional dissipation. The results presented here are from joint papers with C. Cao, with D. Chae, and with Q. Jiu, C. Miao and Z. Zhang. (Received February 02, 2013)

1089-35-99 **Meijun Zhu*** (mzhu@ou.edu). *Reversed sharp Hardy-Littlewood-Sobolev inequality.*

We will describe the discovery and proof of the following reversed sharp Hardy-Littlewood-Sobolev inequality for $\alpha > n$: For all nonnegative $F \in L^1(\mathbb{S}^n)$,

$$\|\tilde{I}_\alpha F\|_{L^{\frac{2n}{n-\alpha}}(\mathbb{S}^n)} \geq N_1^*(n, \alpha) \|F\|_{L^{\frac{2n}{n+\alpha}}(\mathbb{S}^n)},$$

where

$$\tilde{I}_\alpha F(\xi) = \int_{\mathbb{S}^n} \frac{F(\eta)}{|\xi - \eta|^{n-\alpha}} dS_\eta, \quad \forall \xi \in \mathbb{S}^n,$$

$$N_1^*(n, \alpha) = \pi^{(n-\alpha)/2} \frac{\Gamma(\alpha/2)}{\Gamma(n/2 + \alpha/2)} \left\{ \frac{\Gamma(n/2)}{\Gamma(n)} \right\}^{-\alpha/n},$$

And equality holds if and only if $F(\xi) = a(1 - \xi \cdot \eta)^{-\frac{n+\alpha}{2}}$ for some $a > 0$ and $\eta \in \mathbb{R}^{n+1}$ with $|\eta| < 1$. This is a joint work with J. Dou. (Received February 05, 2013)

1089-35-101 **Micahel Benfield** (mike.benfield@gmail.com), **Helge Kristian Jensen** (hkjensen@gmail.com) and **Irina A. Kogan*** (iakogan@ncsu.edu). *Geometry of hyperbolic conservative systems.*

We consider general systems of hyperbolic conservation laws in one space dimension. Given the central role that the wave curves play in constructing solutions of such systems, it is natural to ask the question of how the *geometry* of the wave curves affects behavior of the solutions. Since a wave curve is a union of shock and rarefaction parts, the investigation naturally divides into two parts: characterization of the properties encoded in the geometry of rarefaction curves and characterization of the properties encoded in the geometry of shock curves. We will address a question of constructing conservative systems with prescribed rarefaction curves. We next consider the question of how many extensions the resulting systems have. More precisely, we determine on how many arbitrary functions and/or constants extensions of any conservative system with a prescribed eigenframe depend. We also prove that rarefaction curves completely determine shock curves of non-rich, strictly hyperbolic, conservative systems of three equations. (Received February 15, 2013)

- 1089-35-105 **Durga KC** and **Dipendra Regmi*** (dregmi@math.okstate.edu), and **Lizheng Tao** and **Jiahong Wu**. *The 2D Euler-Boussinesq equations with a logarithmically supercritical velocity.*

We study a generalized 2D Euler-Boussinesq system of equations with a logarithmically supercritical velocity. The velocity u is related with vorticity ω through the relation $u = \nabla^\perp \psi$, $\Delta \psi = \Lambda^\sigma \log^\gamma(I - \Delta)\omega$. We establish the global existence and uniqueness, in the case $\gamma \in [0, \frac{1}{2}]$ and $\sigma = 0$, of solutions when the initial data is in a suitable functional setting. (Received February 06, 2013)

- 1089-35-106 **Igor Kukavica** and **Yuan Pei*** (ypei@usc.edu). *An Estimate on the Size of the Singular Set for Solutions of the Navier-Stokes System.*

For a suitable weak solutions of the Navier-Stokes system in a bounded space-time domain D , we estimate the parabolic fractal (or parabolic box-counting) dimension of the singular set and show that it is less than or equal to $45/29$, which is an improvement to the earlier result from (Kukavica 2009). Also, we introduce the new (parabolic) semi-fractal (or β -fractal) dimension and prove that the dimension of the singular set is bounded by $3/2$. In both proofs we use a new test function which is different from the backward heat kernel as used in many other literatures, as well as an improved treatment of the pressure. (Received February 06, 2013)

- 1089-35-126 **Sarbarish Chakravarty*** (schakrav@uccs.edu), Austin Bluffs Pkwy, Colorado Springs, CO 80918. *Inverse problem: construction of KP soliton solutions from wave patterns.*

In this talk we will discuss how to construct an (approximate) solution of the KP equation from a given pattern of small amplitude, long wavelength and primarily unidirectional waves. This can be regarded as an "inverse problem" in the sense that by measuring the angles and locations of the solitary waves in the given pattern with respect to a fixed reference frame it is possible to determine the data necessary to reconstruct the tau-function associated with the KP line-soliton solution. In the talk, we illustrate the inverse problem by taking an explicit example of shallow water wave pattern. (Received February 09, 2013)

- 1089-35-150 **Wenxiong Chen*** (wchen@yu.edu), **Yanqin Fang** and **Ray Yang**. *Dirichlet Problems for Fractional Laplacians.*

Let Ω be the unit ball $B_1(0)$ in \mathbb{R}^n or be the upper half space \mathbb{R}_+^n . Assume $0 < \alpha < 2$. We consider the following Dirichlet problem for semi-linear equations involving fractional Laplacians:

$$\begin{cases} (-\Delta)^{\alpha/2} u = f(u), & x \in \Omega, \\ u = 0, & x \notin \Omega. \end{cases} \quad (1)$$

Instead of applying the commonly used extension method, we study corresponding integral equations directly in the domain Ω . Using the method of moving planes in integral forms, we obtain radial symmetry (when $\Omega = B_1(0)$) and non-existence (when $\Omega = \mathbb{R}_+^n$) of positive solutions.

We will also mention Liouville type theorems for polyharmonic operators with Dirichlet or Navier boundary conditions on upper half spaces. (Received February 11, 2013)

- 1089-35-174 **Mimi Dai*** (mimi.dai@colorado.edu) and **Maria Elena Schonbek**. *Asymptotic Behavior of Solutions to the Liquid Crystal System in $H^m(\mathbb{R}^3)$.*

We study the large time behavior of regular solutions to a nematic liquid crystal system in Sobolev spaces $H^m(\mathbb{R}^3)$ for $m \geq 0$. We obtain optimal decay rates in $H^m(\mathbb{R}^3)$ spaces, in the sense that the rates coincide with the rates of the underlying linear counterpart. The fluid under consideration has constant density and small initial data. (Received February 13, 2013)

- 1089-35-175 **Alexey Cheskidov** and **Mimi Dai*** (mimi.dai@colorado.edu). *Norm Inflation for Generalized Navier-Stokes Equations.*

We consider the incompressible Navier-Stokes equation with a fractional power $\alpha \in [1, \infty)$ of Laplacian in the three dimensional case. We prove the existence of a smooth solution with arbitrary small in $\dot{B}_{\infty, \infty}^{-\alpha}$ initial data that becomes arbitrary large in $\dot{B}_{\infty, \infty}^{-s}$ for all $s > 0$ in arbitrary small time. This extends the result of Bourgain and Pavlović for the classical Navier-Stokes equation which utilizes the fact that the energy transfer to low modes increases norms with negative smoothness indexes. It is remarkable that the space $\dot{B}_{\infty, \infty}^{-\alpha}$ is supercritical for $\alpha > 1$. Moreover, the norm inflation occurs even in the case $\alpha \geq 5/4$ where the global regularity is known. (Received February 13, 2013)

- 1089-35-180 **Igor Szczyrba*** (igor.szczyrba@unco.edu), University of Northern Colorado, Department of Mathematical Sciences, Greeley, CO 80639, and **Martin Burtscher** and **Rafal Szczyrba**. *Computational modeling of brain dynamics in traumatic scenarios – a new universal Brain Injury Criterion.*

Traumatic Brain Injury is a dreadful human ailment that often results in irreversible disability. We numerically model the brain dynamics of various traumatic scenarios such as car accidents, head collisions during football games, and repetitive blows to the head of a boxer. Our computational model is based on a generalization of the Navier-Stokes PDEs that includes an additional nonlinear term to describe the propagation of shear waves in the brain matter, which lead to a straining of neurons. We introduce a modification of the strain matrix that allows us to evaluate the severity of neuronal strain and, consequently, the potential localization of brain damage. We also develop a new universal ‘external’ Brain Injury Criterion (BIC) that is based on the analysis of the temporal evolution of the spatial distribution of energy in the moving skull. Our new criterion unifies two existing criteria that have been developed independently for traumatic head translations and rotations, which use the head acceleration and velocity/acceleration, respectively, as injury predictors. The results of our numerical simulations as well as the BIC predictions can help in developing better protective measures in cars, sport helmets, etc. (Received February 13, 2013)

- 1089-35-187 **Mark A Hoefler*** (mahoefler@ncsu.edu), Mathematics, North Carolina State University, Box 8205, Raleigh, NC 27607. *Perturbed Magnetic Droplet Solitons.*

The Landau-Lifshitz equation with uniaxial anisotropy in two spatial dimensions admits a two-parameter family of propagating, precessing solitary wave solutions called magnetic droplets. Physically relevant perturbations due to weak damping, a slowly varying external magnetic field, and spin torque are considered in the context of soliton perturbation theory. A dynamical systems analysis of the modulation system and direct numerical simulations of the governing PDE demonstrate the conditions under which physical droplets can be nucleated, sustained, accelerated, and controlled. Applications to recent experiments will be presented. (Received February 14, 2013)

- 1089-35-196 **Michael E. Music** (michael.music@uky.edu), Department of Mathematics, 715 Patterson Office Tower, Lexington, KY 40506-0027, **Peter A. Perry*** (perry@ms.uky.edu), Department of Mathematics, 755 Patterson Office Tower, Lexington, KY 40513, and **Samuli Siltanen** (samuli.siltanen@helsinki.fi), Department of Mathematics and Statistics, University of Helsinki, P.O. Box 68, Helsinki, Finland. *Exceptional Circles of Radial Potentials in Two-Dimensional Inverse Scattering.*

The scattering transform for the two-dimensional Schrödinger equation at zero energy is well-understood for potentials of conductivity type, i.e., those that arise in connection with Calderon’s celebrated inverse conductivity problem, but is otherwise poorly understood. The conductivity type potentials correspond to so-called *critical potentials* in Schrödinger operator theory. Motivated by these ideas, we study the scattering transform for families of radial potentials $q_\lambda = q_0 + \lambda w$ where q_0 is radial and of conductivity type, w is a positive radial bump function and $\lambda \in \mathbb{R}$. We show that, for $\lambda < 0$, the scattering transform \mathbf{t}_λ has strong singularities. We will present both analytic and numerical results. We will also discuss possible connections with well-posedness and blow-up for the Novikov-Veselov equation, which is formally conjugated to a linear system by this transform. (Received February 14, 2013)

- 1089-35-200 **Vishal Vasan*** (vasan@math.psu.edu). *Numerical solution of the time dependent water-wave equations.*

In this talk I shall present a method to solve for the time dependent motion of the free surface of a fluid. I shall discuss the advantages and applicability of this method as well as compare the method with well-known techniques that follow from the work of Craig & Sulem (1993). (Received February 14, 2013)

- 1089-35-223 **Stephane Lafortune*** (lafortunes@cofc.edu), Department of Mathematics, College of Charleston, 175 Calhoun Street, Robert Scott Smalls building, room 339, Charleston, SC 29401, and **Andrew N.W. Hone**. *Stability of solutions for peakon equations.*

The Camassa-Holm equation was originally derived as an asymptotic equation in shallow water wave theory. Among its many interesting mathematical properties, which include complete integrability, perhaps the most striking is the fact that it admits peakon solutions. These are solitary waves (or solitons) with a peaked shape corresponding to a discontinuous first derivative. There is a one-parameter family of generalized Camassa-Holm equations, most of which are not integrable, but which all also admit peakon solutions. Numerical studies indicated changes in the stability properties of these and other solutions as the parameter varies through the family. In this presentation, I describe analytical results on one of these bifurcation phenomena, showing that

in a suitable parameter range there are stationary solutions which are orbitally stable. (Received February 15, 2013)

1089-35-224 **Mathew Johnson*** (matjohn@math.ku.edu), 1460 Jayhawk Blvd., Lawrence, KS 66045, and **Pascal Noble, L. Miguel Rodrigues** and **Kevin Zumbrun**. *On the Spectral Stability of Viscous Roll Waves.*

Viscous roll waves are a well observed phenomenon occurring in shallow water flow down an inclined ramp, generated by competition between gravitational force and friction along the bottom. Such patterns have been used to model phenomena in several areas of engineering, including landslides, river and spillway flow, and the topography of sand dunes and sea beds. While their stability properties have been much studied numerically, experimentally, and by formal asymptotics, a rigorous investigation of the spectral stability of such waves has so far been lacking. In this talk, we discuss recent progress in this direction. In particular, we report on the stability of such roll waves near the onset of instability in the viscous St. Venant equations for shallow water flow. In this limit, the governing amplitude equation reduces to a dispersion modified Kuramoto-Sivashinsky equation in the zero-dissipation limit, and can hence be viewed as a singular perturbation of the integrable KdV equation. Utilizing asymptotic ODE theory, direct Evans function calculations, and Whitham modulation theory, we are able to reduce the stability of such Kuramoto-Sivashinsky waves to the numerical evaluation of an elliptic integral. (Received February 15, 2013)

1089-35-227 **Andrea R. Nahmod** and **Natasa Pavlovic*** (natasa@math.utexas.edu), The University of Texas at Austin, Department of Mathematics, 2515 Speedway, Austin, TX 78712, and **Gigliola Staffilani**. *Almost sure existence of global weak solutions for Navier-Stokes equations.*

In this talk we consider the periodic Navier-Stokes equations and address the question of long time existence of weak solutions for super-critical initial data both in $d = 2, 3$. For $d = 2$ we address uniqueness as well. In particular, we show that by randomizing in an appropriate way the initial data in $H^{-\alpha}(\mathbb{T}^d)$, $d = 2, 3$ (for some $\alpha = \alpha(d) > 0$) which is below the scaling invariant Sobolev space, as well as below the space L^2 where one has available deterministic constructions of weak solutions, one can construct a global in time weak solution to Navier-Stokes equations. Such solution is unique when $d = 2$. (Received February 15, 2013)

1089-35-239 **Jann-Long Chern** and **Chun-Hsiung Hsia*** (willhsia@ntu.edu.tw), Department of Mathematics, National Taiwan University, No 1, Sec 4, Roosevelt Rd, Taipei, 10617, Taiwan, and **Chang-Shou Lin** and **Wadade Hidemitsu**. *On semilinear elliptic equations involving Sobolev and Sobolev-Hardy critical nonlinearities with singularities on the boundary.*

We consider a series of elliptic partial differential equations arising from the study of the extremal functions for Caffarelli-Kohn-Nirenberg (CKN)'s inequalities. By assuming the respective negative/positive curvature of the singularity on the boundary, Ghoussoub-Kang showed the existence of positive solutions on the Dirichlet/Neuman problem, respectively. Recently, in collaboration with Lin and Wadade/ Wadade and Chern respectively, we have remarkably improved the existence theorems for Dirichlet/Neumann problems. In particular, regarding the Neumann problem, we get rid of the curvature constraint. (Received February 16, 2013)

1089-35-243 **John Villavert*** (john.villavert@colorado.edu), Department of Applied Mathematics, 526 UCB, Boulder, CO 80309-0526. *Shooting with Degree Theory: Existence Results for Some Weighted Polyharmonic Systems.*

The existence of positive solutions to a general class of non-autonomous, semilinear elliptic systems including weighted Lane–Emden and Hardy–Littlewood–Sobolev type systems is shown. This is achieved by adopting a novel framework that implements the classical shooting method enhanced by the degree theory. Namely, a target map is first constructed which aims the shooting method, then the non-degeneracy conditions are introduced which guarantees the continuity of this target map. This continuity property in conjunction with the degree theory will show the target map is onto. Then it is illustrated how the surjectivity of the map combined with a Liouville type theorem for the corresponding Dirichlet problem will imply the existence of positive solutions to the class of systems in consideration. (Received February 17, 2013)

1089-35-245 **Susan Friedlander** (susanfri@usc.edu), 3620 S Vermont Ave, KAP 108, Los Angeles, CA 90089, and **Walter Rusin*** (wrusin@usc.edu), 3620 S Vermont Ave, KAP 108, Los Angeles, CA 90089. *Active scalar equations and the second iterate.*

We consider an iterative resolution scheme for a broad class of active scalar equations with a fractional power γ of the Laplacian and focus our attention on the second iterate. The main objective of our work is to analyze

boundedness properties of the resulting bilinear operator. Our results are two-fold: we prove continuity of the bilinear operator in $\dot{B}_{1,\infty}^0$ - in the critical regime $\gamma = 1/2$; for equations with an even symbol we show that the $B_{\infty,q}^{-\gamma}$ -regularity, where $q > 2$, is in a sense a minimal necessary requirement on the solution. (Received February 17, 2013)

1089-35-253 **Kenichi Maruno*** (kmaruno@utpa.edu). *A geometric approach of discretizations of some partial differential equations.*

In a series of our papers, we have investigated integrable discretizations of nonlinear evolution equations in which loop-type and cusp-type soliton solutions exist. In these studies, discrete hodograph transformations, tau-functions and bilinear equations have played important roles. Recently, we found that a geometric formulation of integrable PDEs plays an important role in discretizations. In this talk, we show a geometric approach of discretizations of some partial differential equations. This is a part of joint work with Bao-Feng Feng, Junichi Inoguchi, Kenji Kajiwara and Yasuhiro Ohta. (Received February 17, 2013)

1089-35-255 **Changyou Wang*** (cywang@ms.uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40506, and **Jay Hineman** (hineman@ms.uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40506. *Well-posedness of nematic liquid crystal flows in $L_{uloc}^3(\mathbb{R}^3)$.* Preliminary report.

In this talk, I will establish the local well-posedness of the nematic liquid crystal flow in the scaling invariant space, uniformly locally L^3 -space in \mathbb{R}^3 , provided that such a norm of the initial data is small. This is a joint work with Jay Hineman. (Received February 17, 2013)

1089-35-275 **Ze Cheng*** (ze.cheng@colorado.edu), 1350 20th Street, Apt. K-35, Boulder, CO 80302, and **Congming Li**. *Discrete Maximum Principle on The Hardy-Littlewood-Sobolev Inequality.*

In this talk, we study discrete Hardy-Littlewood-Sobolev (HLS) Inequality in a "critical" case, where the original inequality fails. For this critical case, we derive a finite form of HLS inequality with logarithm correction. Then we obtain a sharp estimate for the best constant by treating it as an optimization problem. By studying the corresponding Euler-Lagrange equation, we prove the uniqueness of nontrivial non-negative critical point, and therefore, the optimizer is unique. As a consequence, symmetry property of the optimizer is obtained. Furthermore, a discrete version of maximum principle is introduced, and as an application, we prove certain monotonicity of the optimizer. (Received February 18, 2013)

1089-35-277 **C DENG*** (dengxznu@gmail.com), Penn State University, PA , and **X Yao** (yaoxiaohua@ccnu.edu.cn), , Peoples Rep of China. *Ill-posedness for the Navier-Stokes equations in Triebel-Lizorkin space in \mathbb{R}^3 .*

In this paper, we study the ill-posedness of the Navier-Stokes equations in Triebel-Lizorkin spaces in the whole three dimensional space by constructing some special smooth initial data with finite energy, which naturally connects the Koch-Tataru's well-posedness work [Adv Math, 2001] and Bourgain-Pavlovic's ill-posedness work [JFA, 2008]. (Received February 18, 2013)

1089-35-278 **C DENG*** (dengxznu@gmail.com) and **X Yao** (yaoxiaohua@ccnu.edu.cn), , Peoples Rep of China. *Well-posedness for the 3D generalized Navier-Stokes equations in the Triebel-Lizorkin space framework.*

In this paper, we study the well-posedness result for the 3D generalized Navier-Stokes equations (gNS) by establishing a new time-space type $L_p(dx)$ - $L_q(dt)$ bilinear estimate. Combining the key bilinear estimate, we also prove ill-posedness of this gNS. (Received February 18, 2013)

1089-35-290 **Stan Alama*** (alama@mcmaster.ca), Department of Mathematics & Statistics, McMaster University, 1280 Main St. West, Hamilton, ON L8S4J8, Canada, and **Qi Gao** (gaoq@math.mcmaster.ca), Department of Mathematics & Statistics, McMaster University, 1280 Main Street West, Hamilton, ON L8S4J8, Canada. *Vortices for a Two-Component Ginzburg-Landau System.*

We study Ginzburg-Landau equations for a complex vector order parameter $\Psi = (\psi_+, \psi_-) \in \mathbb{C}^2$. We consider entire solutions in the plane \mathbb{R}^2 with given degrees $n_{\pm} \in \mathbb{Z}$ at infinity, which arise by blowing up around the core of a vortex in the singular London limit. Among these solutions are the equivariant solutions, for which we prove existence, uniqueness, and monotonicity properties, and determine their stability. These results are obtained via a priori estimates and a comparison theorem for elliptic systems. (Received February 18, 2013)

1089-35-300 **Douglas E Baldwin*** (douglas.baldwin@colorado.edu). *Dispersive shock wave interactions and asymptotics.*

Dispersive shock waves (DSWs) associated with the Korteweg–de Vries (KdV) equation are discussed. First, two-step data are investigated with numerical methods and with Whitham’s averaging method: when two DSWs interaction, two-phase dynamics appear at intermediate times but tend to a single-phase DSW. The long-time asymptotic solution for general, step-like data is then found. This solution is found using the inverse scattering transform (IST) and matched-asymptotic analysis. Despite multiphase dynamics at intermediate times, it’s found that interacting DSWs eventually merge to form a single-phase DSW. The boundary data determine this DSW’s form; the initial data determine its location. Initial data also determine the number and location of any solitons. (Received February 18, 2013)

1089-35-310 **Ray Yang*** (ryang@cims.nyu.edu). *On higher order extensions for the fractional Laplacian.*

The technique of Caffarelli and Silvestre, characterizing the fractional Laplacian as the Dirichlet-to-Neumann map for a function U satisfying an elliptic equation in the upper half space with one extra spatial dimension, is shown to hold for general positive, non-integer orders of the fractional Laplace operator, by showing an equivalence between the H^s norm on the boundary and a suitable higher-order seminorm of U . (Received February 18, 2013)

1089-35-319 **Peter D. Miller*** (millerpd@umich.edu). *On the stability analysis of periodic sine-Gordon traveling waves.*

We study the spectral stability properties of periodic traveling waves in the sine-Gordon equation, including waves of both subluminal and superluminal propagation velocities as well as waves of both librational and rotational types. We prove that only subluminal rotational waves are spectrally stable and establish exponential instability in the other three cases. Our proof corrects a frequently cited one given by Scott. This is joint work with C. K. R. T. Jones, R. Marangell, and R. Plaza. (Received February 18, 2013)

1089-35-324 **Sergey A Dyachenko*** (sdyachen@unm.edu), 1 University of New Mexico, Albuquerque, NM 87131, and **Pavel M Lushnikov**. *Solitons in dipolar BEC with $1/r$ interatomic potential.* Preliminary report.

Dipolar atoms in gas under special conditions can be made to exhibit $1/r$ interatomic potential. The resulting system can be modelled with Nonlocal Nonlinear Schrodinger equation. The system has a number of remarkable features, such as the soliton solutions and long-range interactions. (Received February 18, 2013)

1089-35-341 **Monica Lazzo and Paul G Schmidt*** (pgs@auburn.edu). *Oscillatory entire solutions of polyharmonic equations with power nonlinearities.*

Elliptic systems or higher-order equations with power or power-like nonlinearities have recently garnered much attention. Most of the research (on boundary-value problems, large solutions and their blow-up behavior, entire solutions and their asymptotic behavior) is concerned with positive solutions; much less is known about sign-changing solutions. We recently established the existence and uniqueness (up to scaling) of oscillatory entire radial solutions for a subcritical biharmonic equation with power nonlinearity. We discuss the asymptotic behavior of these solutions and possible generalizations for polyharmonic problems. (Received February 18, 2013)

1089-35-347 **Matti Lassas and Jennifer L Mueller*** (mueller@math.colostate.edu), Department of Mathematics, Colorado State University, Fort Collins, CO 80523, and **Samuli Siltanen, Andreas Stahel and Ryan Croke**. *Numerical solution of the Novikov-Veselov equation by the ISM and transverse instability of plane-wave soliton solutions.*

The Novikov-Veselov (NV) equation is a dispersive (2+1)-dimensional nonlinear evolution equation generalizing the (1+1)-dimensional KdV equation. Here, the inverse scattering method is used as a computational tool for computing evolutions of the NV equation. Evolutions of conductivity-type initial data computed by the inverse scattering method are compared to those computed using a semi-implicit method using finite differences in the spatial variables, Crank-Nicolson in time, and fast Fourier transforms for the auxiliary equation. The two methods and are observed to coincide with significant accuracy. In addition, we prove instability of plane wave soliton solutions of the NV equation to transverse perturbations. To investigate the behavior of the perturbations, a hybrid semi-implicit/spectral numerical scheme was developed, applicable to other nonlinear PDE systems. Numerical simulations of the evolution of transversely perturbed plane wave solutions and multisoliton solutions are presented. (Received February 18, 2013)

1089-35-363 **Gino Biondini***, biondini@buffalo.edu, and **Emily Fagerstrom** and **Gregor Kovacic**. *On the Maxwell-Bloch equations and the focusing nonlinear Schroedinger equation with non-zero boundary conditions and the Benjamin-Feir instability*. Preliminary report.

The inverse scattering transform (IST) for the Maxwell-Bloch equations (MBE) and the focusing nonlinear Schroedinger equation (NLSE) with non-zero boundary conditions (NZBCs) is presented. A rich class of soliton solutions is discussed, which includes as special cases the Peregrine solution, the Ma solutions, and the Akhmediev solutions. Moreover, it is proved that no area theorem exists for the scattering problem: there exist initial conditions with arbitrarily small amplitudes that give rise to a discrete spectrum. These results suggest that the solitons of the problem are the underlying vehicle for the Benjamin-Feir instability (Received February 19, 2013)

1089-35-368 **Ran Zhuo*** (zhuoran1986@126.com) and **Fengquan Li**. *Liouville type theorems for Schrödinger system in a half space*.

Let R_+^n be the upper Euclidean space, we study positive solutions of the following higher order Schrödinger systems:

$$\begin{cases} (-\Delta)^m u(x) = u^{\beta_1}(x)v^{\gamma_1}(x), & \text{in } R_+^n, \\ (-\Delta)^m v(x) = u^{\beta_2}(x)v^{\gamma_2}(x), & \text{in } R_+^n, \end{cases} \quad (1)$$

with Dirichlet boundary conditions or Navier boundary conditions.

We show that these problems are closely related to integral systems. Combining method of moving planes in integral forms with a certain type of Kelvin transforms, we prove that the positive solutions are either monotone increasing or are rotationally symmetric. In either cases, we derive a contradiction and thus establish the non-existence of solutions of the integral systems. Here we only assume local integrability for the solutions. (Received February 19, 2013)

1089-35-376 **Steve Shkoller*** (shkoller@math.ucdavis.edu), Department of Mathematics, Davis, CA 95616. *Finite-time splash and splat singularities for the 3-D free-surface Euler equations*.

We prove that the 3-D free-surface incompressible Euler equations with regular initial geometries and velocity fields have solutions which can form a finite-time “splash” (or “splat”) singularity, wherein the evolving 2-D hypersurface, the moving boundary of the fluid domain, self-intersects at a point (or on surface). Such singularities can occur when the crest of a breaking wave falls unto its trough, or in the study of drop impact upon liquid surfaces. Our approach is founded upon the Lagrangian description of the free-boundary problem, combined with a novel approximation scheme of a finite collection of local coordinate charts; as such we are able to analyze a rather general set of geometries for the evolving 2-D free-surface of the fluid. We do not assume the fluid is irrotational, and as such, our method can be used for a number of other fluid interface problems, including compressible flows, plasmas, as well as the inclusion of surface tension effects. (Received February 19, 2013)

1089-35-390 **Jerry L Bona** and **Hongqiu Chen*** (hchen1@memphis.edu), Department of Mathematical Sciences, University of Memphis, Memphis, TN 38152. *Well-posedness for regularized nonlinear dispersive wave equations*.

In this talk, we consider the initial-value problem

$$\left. \begin{aligned} u_t + u_x + g(u)_x + Lu_t &= 0, & x \in \mathbb{R}, & t > 0, \\ u(x, 0) &= u_0(x), & x \in \mathbb{R}, \end{aligned} \right\} \quad (1)$$

where $u = u(x, t)$ is a real-valued function, L is a Fourier multiplier operator with real symbol $\alpha(\xi)$, say, and g is a smooth, real-valued function of a real variable. Equations of this form arise as models of wave propagation in a variety of physical contexts. Here, fundamental issues of local and global well-posedness are established for L_p , H^s and bore-like or kink-like initial data. In the special case where $\alpha(\xi) = |\xi|^r$ wherein $r > 1$ and $g(u) = \frac{1}{2}u^2$, (1) is globally well-posed in time if s and r satisfy a simple algebraic relation. (Received February 19, 2013)

1089-35-399 **Bo Guan*** (guan@math.osu.edu). *Estimates for fully nonlinear elliptic equations on real or complex manifolds*.

We report some recent progress in our effort to search for general methods to overcome difficulties in deriving a priori estimates for solutions of fully nonlinear elliptic equations on real or complex manifolds. We are concerned with both global estimates for equations on closed manifolds and boundary estimates for Dirichlet problems. Our methods work for a wide range of classes of fully nonlinear elliptic and parabolic equations under conditions which in many cases are close to optimal, and give new existence results for the Dirichlet problems in real and complex Euclidean space. (Received February 19, 2013)

37 ► *Dynamical systems and ergodic theory*

1089-37-56 **Todd Fisher*** (tfisher@math.byu.edu), Dept of Mathematics, Brigham Young University, Provo, UT 84602, and **Rafael Potrie** and **Martin Sambarino**. *Dynamical coherence and intrinsic ergodicity for partially hyperbolic diffeomorphisms isotopic to Anosov*.

We will discuss partially hyperbolic diffeomorphisms that are isotopic to a hyperbolic toral automorphism and contained in a connected component. If the splitting of the partially hyperbolic diffeomorphism satisfies certain dimensional constraints, then we show the diffeomorphism is dynamically coherent. We then prove that if the center direction is one dimensional, then the topological entropy is locally constant and there is a unique measure of maximal entropy. (Received January 24, 2013)

1089-37-58 **David Samuel Simmons*** (simmons.465@osu.edu), 231 W. 18th St, Columbus, OH 43210. *Diophantine approximation and the geometry of limit sets in Gromov hyperbolic metric spaces*.

Let (X, d) be a Gromov hyperbolic metric space, and let ∂X be the Gromov boundary of X . Fix a group $G \leq \text{Isom}(X)$ and a point $\xi \in \partial X$. We consider the Diophantine approximation of a point $\eta \in \partial X$ by points in the set $G(\xi)$. Our results generalize the work of many authors, in particular Patterson ('76) who proved most of our results in the case that G is a geometrically finite Fuchsian group of the first kind and ξ is a parabolic fixed point of G . (Received January 25, 2013)

1089-37-113 **Robert G Niemeyer*** (niemeyer@math.unm.edu), Department of Mathematics & Statistics, MSC01 1115, 1 University of New Mexico, Albuquerque, NM 87131, **Michel L Lapidus** (lapidus@math.ucr.edu), 900 University Ave., Surge Bldg., Department of Mathematics, Riverside, CA 92512, **Joe P. Chen** (joe.p.chen@cornell.edu), Cornell University, 310 Malott Hall, Department of Mathematics, Ithaca, NY 14853, and **Robyn L Miller** (rmiller@math.cornell.edu), Cornell University, 310 Malott Hall, Department of Mathematics, Ithaca, NY 14853. *Recurrent orbits and nontrivial paths in particular fractal billiard tables*.

In this talk, we will present examples of sequences of compatible periodic orbits of prefractal billiard tables. In particular, we will demonstrate the existence of such sequences for the Koch snowflake fractal billiard table, a self-similar Sierpinski carpet billiard table and the T-fractal billiard table. In each case, we will see that certain sequences of compatible periodic orbits exhibit interesting dynamical behavior and, in some cases, converge to recurrent (periodic) orbits. We will close by providing possible approaches to determining a wider class of recurrent orbits in each fractal billiard table. The material presented will be summarizing separate joint projects with M. L. Lapidus, J. P. Chen and R. L. Miller. (Received February 07, 2013)

1089-37-128 **Howard Masur*** (masur@math.uchicago.edu), **Keith Burns**, **Carlos Matheus Santos** and **Amie Wilkinson**. *Mixing Properties of the Weil-Petersson geodesic flow*. Preliminary report.

The Weil-Petersson metric on the moduli space of hyperbolic metrics on a surface of genus g with n punctures is known to be ergodic and mixing. In this talk I will discuss some preliminary results on the rate of mixing of the flow. (Received February 09, 2013)

1089-37-130 **Christian Wolf*** (cwolf@ccny.cuny.edu), Department of Mathematics, New York, NY 10031, and **Tamara Kucherenko**, Department of Mathematics, New York, NY 10031. *On rotation entropy*.

For a continuous map f on a compact metric space we study the entropy of the generalized rotation set $R(\Phi)$. Here $\Phi = (\phi_1, \dots, \phi_m)$ is a m -dimensional continuous potential and $R(\Phi)$ is the set of all μ -integrals of Φ and μ runs over all f -invariant probability measures. We study the relation between $R(\Phi)$ and the set of all statistical limits $R_{P_t}(\Phi)$. It turns out that in general these sets differ but under certain conditions $R(\Phi) = R_{P_t}(\Phi)$. Next we consider the entropy function $w \mapsto H(w)$, $w \in R(\Phi)$. We establish a variational principle for the entropy function and show that for certain non-uniformly hyperbolic systems $H(w)$ is determined by the growth rate of those hyperbolic periodic orbits whose Φ -integrals are close to w . Moreover, discuss regularity properties of the entropy function. (Received February 17, 2013)

1089-37-138 **Ryan Peckner*** (rpeckner@math.princeton.edu). *Uniqueness of the measure of maximal entropy for the squarefree flow*.

The squarefree flow is a natural dynamical system whose topological and ergodic properties are closely linked to the behavior of squarefree numbers. We prove that the squarefree flow carries a unique measure of maximal

entropy and describe the structure of the associated measure-preserving dynamical system. Our method involves first studying approximations arising from finite collections of prime numbers, then taking a limit under Ornstein's \bar{d} -metric in order to consider all primes simultaneously. This is accomplished by exhibiting uniform Gibbs bounds for a sequence of sofic systems and constructing explicit joinings between them in order to estimate their \bar{d} -distances. (Received February 10, 2013)

1089-37-148 **Vaughn Climenhaga*** (climaha@math.uh.edu), **Daniel J. Thompson** and **Kenichiro Yamamoto**. *Large deviations and non-uniform specification properties.*

We establish a large deviations principle for symbolic systems satisfying a certain form of non-uniform hyperbolicity. Namely, there should be a collection of words (finite orbit segments) with the specification property, and this set of words should be asymptotically statistically dense in the language of the shift space. Then if m is a weak Gibbs measure relative to this collection of words, the system satisfies a large deviations principle with reference measure m . Prior work has shown that existence of such weak Gibbs measures can be guaranteed via an additional thermodynamic hypothesis. (Received February 11, 2013)

1089-37-201 **David Aulicino*** (aulicino@math.uchicago.edu), Department of Mathematics, University of Chicago, 5734 University Avenue, Chicago, IL 60637. *Affine Invariant Submanifolds with Completely Degenerate Kontsevich-Zorich Spectrum.* Preliminary report.

I will introduce the Lyapunov exponents of the Teichmüller geodesic flow on the moduli space of Abelian differentials and give some background on what is known about them. Then I will consider the problem of classifying all affine invariant submanifolds with the property that they have the maximal number of zero Lyapunov exponents with respect to the Kontsevich-Zorich cocycle. I will prove that any such submanifold is an arithmetic Teichmüller curve. By a result of Martin Moeller, it must occur in genus 3, 4, or 5. (Received February 14, 2013)

1089-37-206 **Godofredo Iommi**, **Thomas Jordan** and **Mike Todd*** (mjt20@st-andrews.ac.uk), Mathematics Institute, North Haugh, St Andrews, Fife KY16 9SS, United Kingdom. *Thermodynamics of flows with cusps.*

I'll consider the thermodynamic formalism for semi-flows $\Phi = (\varphi_t)_{t \geq 0}$ which can be viewed as a discrete dynamical system $f : X \rightarrow X$ with a roof function $\tau : X \rightarrow [0, \infty]$. This means that $\varphi_t(x, s) = (x, s + t)$ whenever $s + t \in [0, \tau(x))$, $\varphi_t(x, s) = (f(x), 0)$ when $s + t = \tau(x)$, and so on. The standard thermodynamic theory deals with the case where the roof function is uniformly bounded away from zero. I'll discuss our study of pressure and equilibrium states where the infimum of the roof function is 0: the cusp case. I'll give examples where the cusp improves the thermodynamics and where it does not. (Received February 15, 2013)

1089-37-210 **Paul Reschke*** (presch2@uic.edu). *Salem Numbers and Abelian Surface Automorphisms.* We will discuss complex surface automorphisms with positive entropy, addressing in particular the question of what values of entropy can be achieved by such automorphisms. A fundamental result in this area is that any positive value of entropy is necessarily the logarithm of a Salem number. However, a Salem number in general need not necessarily give the entropy of some automorphism. We will present a complete characterization of the entropies of automorphisms of two-dimensional complex tori, with a detailed focus on automorphisms of abelian surfaces. We will also review results and open questions for automorphisms of rational surfaces and K3 surfaces. (Received February 15, 2013)

1089-37-216 **Ronnie Lee Pavlov*** (rpavlov@du.edu), 2360 S. Gaylord St., University of Denver, Denver, CO 80208. *Shifts of finite type with nearly full entropy.*

\mathbb{Z}^d shifts of finite type (or SFTs) are a well-studied class of topological dynamical systems. Informally, a \mathbb{Z}^d -SFT X is the set of all functions from \mathbb{Z}^d to a finite alphabet A which satisfy a finite set of "local rules." If these rules involve only pairs of adjacent letters, then the SFT is called "nearest neighbor."

It is well-known that for $d = 1$, any mixing \mathbb{Z} -SFT has a unique measure of maximal entropy (the Parry measure). However, it was shown by Burton and Steif that \mathbb{Z}^d SFTs can have multiple measures of maximal entropy for $d > 1$, even if one assumes that the SFT satisfies extremely strong mixing properties such as strong irreducibility.

We present a new sufficient condition for a \mathbb{Z}^d -SFT to have a unique m.m.e., which is expressed purely in terms of topological entropy. Namely, for any d , there is a constant $\beta(d) > 0$ so that any nearest-neighbor \mathbb{Z}^d -SFT X with alphabet A and topological entropy at least $(\log |A|) - \beta(d)$ has a unique m.m.e. We will also present some examples and background to illustrate how this result compares to other sufficient conditions in the literature. (Received February 15, 2013)

1089-37-225 **Ryan Broderick*** (ryan@math.northwestern.edu), Department of Mathematics, Northwestern University, 2033 Sheridan Road, Evanston, IL 60208-2730, and **Lior Fishman** and **David Simmons**. *Strong C^1 Incompressibility, Badly Approximable Linear Forms, and Schmidt's Game.*

We will discuss a variant of Schmidt's winning property which produces a class of sets that is closed under countable intersection and under taking images by C^1 diffeomorphisms. In particular, the countable intersection of C^1 diffeomorphic images of such a set meets any sufficiently regular fractal in a set of full Hausdorff dimension. In a joint work with L. Fishman and D. Simmons, we have shown that the set of badly approximable linear forms is a member of this class. (Received February 15, 2013)

1089-37-229 **Max Glick*** (maxglick@umich.edu). *Dynamical systems that become singular in both directions.*

I will be discussing work in progress, inspired by a result of R. Schwartz about the pentagram map (a dynamical system defined for plane polygons). The result states that a polygon sent by the pentagram map to a single point must also be mapped by a certain iterate of the inverse pentagram map to a single line. The degeneracies of these end polygons make it impossible to carry the dynamics any farther in either direction.

It appears that a good number of discrete dynamical systems exhibit similar behavior. In each case, encountering an extreme singularity implies that iterating the inverse system will lead to another such singularity after a predictable number of steps. Some of the systems, including the pentagram map, can be described in terms of cluster algebras. In this language propagation corresponds to bipartite mutations in a certain Y-pattern, and the singularities occur when all the y-variables about to be mutated equal -1. (Received February 15, 2013)

1089-37-279 **Bryce A. Weaver*** (weavbryc@indiana.edu), Rawles Hall, 831 East 3rd St, Bloomington, IN 47404. *Counting geodesics connecting two base points through 'sectors'.* Preliminary report.

For surfaces whose geodesic flows have certain properties, including a Margulis measure, we show that there are two families of measures on the unit spheres. These measures give precise multiplicative asymptotic growth rates for geodesics connecting their base points through 'sectors'. (Received February 18, 2013)

1089-37-280 **Nicolai Haydn** (nhaydn@usc.edu), **Matthew Nicol*** (nicol@math.uh.edu), **Sandro Vaienti** (vaienti@cpt.univ-mrs.fr) and **Licheng Zhang** (xiyao.fei@gmail.com). *Central limit theorems for the shrinking target problem.*

Suppose $B_i := B(p, r_i)$ are nested balls of radius r_i about a point p in a dynamical system (T, X, μ) . The question of whether $T^i x \in B_i$ i. o. for μ a.e. x is often called the shrinking target problem. In many dynamical settings it has been shown that if $E_n := \sum_{i=1}^n \mu(B_i)$ diverges then there is a quantitative rate of entry and $\lim_{n \rightarrow \infty} \frac{1}{E_n} \sum_{j=1}^n 1_{B_i}(T^j x) \rightarrow 1$ for μ a.e. $x \in X$. This is a self-norming type of strong law of large numbers. We establish self-norming central limit theorems (CLT) of the form $\lim_{n \rightarrow \infty} \frac{1}{a_n} \sum_{i=1}^n [1_{B_i}(T^i x) - \mu(B_i)] \rightarrow N(0, 1)$ (in distribution) for a variety of hyperbolic and non-uniformly hyperbolic dynamical systems, the normalization constants are $a_n^2 \sim E[\sum_{i=1}^n 1_{B_i}(T^i x) - \mu(B_i)]^2$. Dynamical systems to which our results apply include smooth expanding maps of the interval, Rychlik type maps, certain non-uniformly expanding maps of the interval and, in higher dimensions, piecewise expanding maps. (Received February 18, 2013)

1089-37-281 **Jayadev Athreya** (jonchaika@gmail.com) and **Jon Chaika*** (jonchaika@gmail.com), 1018 E 54th st, #2, Chicago, IL 60615. *The set of minimal but not uniquely ergodic 4-IETs has Hausdorff dimension $2 \frac{1}{2}$.*

We prove that the set of minimal but not uniquely ergodic 4-IETs has Hausdorff dimension $2 \frac{1}{2}$ in a 3 dimensional space. This is joint work with J. Athreya. (Received February 18, 2013)

1089-37-282 **John T Griesmer***, jtgriesmer@gmail.com. *Title: Sumsets with one dense and one infinite summand.*

Abstract: We study sets of integers of the form $A + B := \{a + b \mid a \in A, b \in B\}$, where A is infinite and B has positive upper Banach density. We exploit a spectral property of the special measure preserving systems (nilsystems) which arise in the study of dense sets of integers, and we find that under our hypotheses, $A + B$ must contain many kinds of finite configurations which may not appear in an arbitrary dense set of integers. This investigation leads to some natural and elementary questions about sets of (single) recurrence. (Received February 18, 2013)

1089-37-295 **Chinmaya Gupta, William Ott** and **Andrew Torok*** (torok@math.uh.edu), Department of Mathematics, University of Houston, Houston, TX 77204-3008. *Memory loss for time-dependent piecewise expanding systems in higher dimension.*

We prove a counterpart of exponential decay of correlations for non-stationary systems. Namely, given two probability measures absolutely continuous with respect to a reference measure, their quasi-Hölder distance (and in particular their L^1 distance) decreases exponentially under action by compositions of arbitrarily chosen maps close to those that are both piecewise expanding and mixing in a certain sense. The novelty of the result is the higher-dimensional setting. (Received February 18, 2013)

1089-37-313 **Mark Pollicott***, Department of Mathematics, Warwick University, Coventry, CV4 7AL, United Kingdom. *Thermodynamic Formalism, Riemann surfaces, the Laplacian and its determinant.* Preliminary report.

Beginning with the early work of Morse and Hedlund, one of the classical approaches to studying geodesics on negatively curved Riemann surfaces has been via symbolic dynamics. This approach gives a direct application of "Thermodynamic Formalism" (e.g., Pressure, Gibbs measures and Ruelle Operators) to geometric problems. In particular, we shall describe how this method can be used to analyze the determinant of the laplacian for families of non-compact surfaces. We will consider, in particular, the example of once punctured tori and their relation with conjectures of Sarnak. (Received February 18, 2013)

1089-37-331 **Tamara Kucherenko*** (tkucherenko@ccny.cuny.edu), Department of Mathematics, The City College of New York, NAC 8/133, Convent Ave at 138th Street, New York, NY 10031, and **Christian Wolf**. *The geometry of generalized rotation sets.*

For a continuous map f on a compact metric space we study the geometry of the generalized rotation set $\text{Rot}(\Phi)$. Here $\Phi = (\phi_1, \dots, \phi_m)$ is a m -dimensional continuous potential and $\text{Rot}(\Phi)$ is the set of all integrals of Φ with respect to f -invariant probability measures. It is easy to see that the rotation set is a compact and convex subset of \mathbb{R}^m . We study the question if every compact and convex set is attained as a rotation set of a particular set of potentials within a particular class of dynamical systems. We give a positive answer in the case of subshifts of finite type by constructing for every compact and convex set K in \mathbb{R}^m a potential $\Phi = \Phi(K)$ with $\text{Rot}(\Phi) = K$. (Received February 18, 2013)

1089-37-355 **Huyi Hu*** (hhu@math.msu.edu), **Yujun Zhu** and **Yunhua Zhou**. *Quasi-stability and quasi-shadowing for partially hyperbolic diffeomorphisms.* Preliminary report.

The motivation of the work is to study topological properties of partially hyperbolic systems which are similar to those of uniformly hyperbolic systems. We try to obtain some properties similar to these of uniformly hyperbolic systems by "ignoring" the motions along the center direction.

We show that any partially hyperbolic systems (i) are quasi-stable in the sense that for any homeomorphism g C^0 -close to f , there exist a continuous map π from M to itself and a family of locally defined continuous maps $\{\tau_x : x \in M\}$, which send points along the center direction, such that

$$\pi \circ g(x) = \tau_{f(x)} \circ f \circ \pi(x) \forall x \in M;$$

and (ii) have quasi-shadowing property in the sense that for any pseudo orbit $\{x_k\}_{k \in \mathbb{Z}}$, there is a sequence of points $\{y_k\}_{k \in \mathbb{Z}}$ shadowing it in which y_{k+1} is obtained from $f(y_k)$ by a motion τ along center direction.

In particular, if f has C^1 center foliation, then we can make the motion τ along the center foliation.

As application we obtain some continuity properties for topological entropy. Also, we show that if the center foliation is uniformly compact, then there is an analogue of spectral decomposition for center nonwandering set. (Received February 19, 2013)

1089-37-373 **Aaron W. Brown*** (brown@math.psu.edu), McAllister Building, Mathematics Department, Penn State University, University Park, PA 16802, and **Federico Rodriguez Hertz**. *Measure rigidity for random surface dynamics.* Preliminary report.

We consider a group Γ of C^2 surface diffeomorphisms preserving a probability measure μ . Under the additional assumptions of positive entropy and the absence of a μ -measurable, Γ -invariant vector field, we show μ is absolutely continuous. In the case μ is a stationary measure, we show either the stable vector field for a typical word is Γ -invariant, or μ is SRB. (Received February 19, 2013)

1089-37-379 **Anushaya Mohapatra** and **William Ott*** (ott@math.uh.edu). *Memory loss for nonequilibrium open dynamical systems.*

We discuss recent results on memory loss (an analog of decay of correlations) for nonequilibrium dynamical systems. By *nonequilibrium* we mean that the dynamical model itself varies in time. Applications include

dynamical processes that evolve in time-varying environments and dynamical systems with slowly varying parameters. Unlike the setting of random dynamical systems, we do not assume that the dynamical model evolves in accord with a statistical distribution. (Received February 19, 2013)

1089-37-401 **Hector E Lomeli*** (lomeli@itam.mx), Current address: Mathematics Dept, The University of Texas at Austin, 2515 Speedway Stop C1200, Austin, TX 78712. *Integrability and Symmetry Reduction for Maps*.

We study diffeomorphisms that have one-parameter families of continuous symmetries. For general maps, in contrast to the symplectic case, the existence of a symmetry no longer implies the existence of an invariant. Conversely, a map with an invariant need not have a symmetry. We show that when a symmetry flow has a global Poincaré section there are coordinates in which the map takes a reduced, skew-product form, and hence allows for reduction of dimensionality. A number of illustrative examples are discussed and the method is compared with traditional reduction techniques. (Joint work with James D. Meiss and Holger Dullin) (Received February 19, 2013)

39 ► *Difference and functional equations*

1089-39-140 **Willy Hereman*** (whereman@mines.edu), Dept. of Applied Mathematics & Statistics, Colorado School of Mines, Chauvenet Hall, 1015 14th Street, Golden, CO 80401, and **Terry Bridgman** (tbridgma@mines.edu), Dept. of Applied Mathematics & Statistics, Colorado School of Mines, Chauvenet Hall, 1015 14th Street, Golden, CO 80401. *Symbolic Computation of Lax Pairs of Systems of Partial Difference Equations Using Consistency Around the Cube*.

A three-step method due to Bobenko & Suris and Nijhoff to derive Lax pairs for scalar partial difference equations is extended to systems which are defined on a quadrilateral and consistent around the cube.

Lax pairs will be presented for several systems including the integrable 2-component potential Korteweg-de Vries lattice system, as well as nonlinear Schrödinger and Boussinesq-type lattice systems. Previously unknown Lax pairs will be presented for systems of partial difference equations recently derived by Hietarinta.

The method is algorithmic and is being implemented in Mathematica. (Received February 11, 2013)

1089-39-154 **Peter Vorobieff*** (kalthoth@unm.edu), Department of Mechanical Engineering, MSC01 1150, The University of New Mexico, Albuquerque, NM 87131, and **Vakhtang Putkaradze**, **Andrea Mammoli** and **Nima Fathi**. *Optimal design of an inflatable, free-standing solar updraft tower*.

A solar chimney uses temperature difference between the air in a greenhouse heated by the sun and the air at an elevation above the greenhouse to produce an updraft flow and harvest its energy. Recently, a novel design was proposed for solar chimneys, with the chimney that generates the updraft implemented as a self-supporting, free-standing stack of inflatable toroidal balloons. Stability of such an inflatable chimney would depend on many factors, including shape, overpressure, wind loading, and buoyancy of the gas used for inflation. Surprisingly, the system of difference equations describing the shape of the tower under fairly realistic constraints allows an explicit solution. (Received February 11, 2013)

41 ► *Approximations and expansions*

1089-41-142 **Peter Robert Massopust*** (massopust@ma.tum.de), Centre of Mathematics, Technische Universität München, Boltzmannstr. 3, 85747 Garching, Germany. *Exponential Splines with Complex Order*.

We introduce the concept of exponential spline of complex order and show that this new class of splines generalizes in a natural way the classical polynomial and exponential splines as well as fractional and complex B-splines. Some properties of exponential splines are discussed. (Received February 11, 2013)

1089-41-254 **Kathy D. Merrill*** (kmerrill@coloradocollege.edu). *Simple n -dimensional wavelet sets*. We present wavelet sets in \mathbb{R}^n , n arbitrary, for dilation by any expansive matrix that has some integer power equal to a scalar matrix. These wavelet sets are simple in that they consist of a finite union of convex sets. (Received February 17, 2013)

42 ► *Fourier analysis*

1089-42-38 **Dorin Ervin Dutkay*** (ddutkay@gmail.com). *The Fuglede conjecture in dimension one.*
We present an overview on the existing results on the Fuglede conjecture about tiling and spectral sets on the real line. (Received January 16, 2013)

1089-42-45 **Dorin Dutkay** and **Gabriel Picioroaga*** (gabriel.picioroaga@usd.edu), Vermillion, SD 57069, and **Myung-Sin Song.** *Orthonormal Bases Generated by Cuntz Algebras.*
We show how some orthonormal bases can be generated by representations of the Cuntz algebra; these include Fourier bases on fractal measures, generalized Walsh bases on the unit interval and piecewise exponential bases on the middle third Cantor set. (Received January 18, 2013)

1089-42-67 **Chun-Kit Lai*** (cklai@math.mcmaster.ca), Department of Mathematics and Statistics, McMaster University, Hamilton, L8S 4K1, Canada, and **Xin-Rong Dai** and **Xing-Gang He.** *Spectral property of Cantor measures with consecutive digits.*
We consider equally-weighted Cantor measures $\mu_{q,b}$ arising from iterated function systems of the form $b^{-1}(x+i)$, $i = 0, 1, \dots, q-1$, where $q < b$. We classify the (q, b) so that they have infinitely many mutually orthogonal exponentials in $L^2(\mu_{q,b})$. In particular, if q divides b , the measures have a complete orthogonal exponential system and hence spectral measures. We then characterize all the maximal orthogonal sets and separate the kind of maximal orthogonal sets into two types: regular and irregular sets. For a regular maximal orthogonal set, we show that its completeness in $L^2(\mu_{q,b})$ is crucially determined by the certain growth rate of non-zero digits in the tail of the b -adic expansions of the elements. Furthermore, we exhibit complete orthogonal exponentials with zero Beurling dimensions. This example shows that classical result of Landau on Fourier frame cannot be directly generalized to fractal settings and answers a question raised by Dutkay et al. (Received January 28, 2013)

1089-42-73 **Matthew Fickus*** (matthew.fickus@afit.edu), AFIT/ENC, 2950 Hobson Way, Wright-Patterson AFB, OH 45433. *Characterizing completions of finite frames.*
Finite frames are possibly-overcomplete generalizations of orthonormal bases. We consider the “frame completion” problem, that is, the problem of how to add vectors to an existing frame in order to make it better conditioned. In particular, we discuss a new, complete characterization of the spectra of the frame operators that arise from those completions whose newly-added vectors have given prescribed lengths. To do this, we build on recent work involving a frame’s eigensteps, namely the interlacing sequence of spectra of its partial frame operators. We discuss how such eigensteps exist if and only if our prescribed lengths are majorized by another sequence which is obtained by comparing our completed frame’s spectrum to our initial one. As such, these results can be viewed as a generalization of the classical Schur-Horn Theorem. Moreover, when such eigensteps exist, we give a simple algorithm called “Chop Kill” that explicitly constructs them. (Received January 31, 2013)

1089-42-74 **Marcin Bownik*** (mbownik@uoregon.edu), Department of Mathematics, University of Oregon, Eugene, OR 97403, and **John Jasper,** Department of Mathematics, University of Missouri, Columbia, MO 65211. *Existence of frames with prescribed norms and frame operator.*

In this talk we present recent results on the existence of frames with prescribed norms and frame operator. These results are equivalent to the Schur-Horn type theorems which describe possible diagonals of positive self-adjoint operators with specified spectral properties. The first infinite dimensional result of this type is due to Kadison who characterized diagonals of orthogonal projections. Kadison’s theorem gives automatically a characterization of all possible sequences of norms of Parseval frames. We present a generalization of this result when the frame operator has a finite spectrum. This talk is based on the joint work with John Jasper. (Received January 31, 2013)

1089-42-120 **Marcin Bownik** and **Darrin Speegle*** (speegled@slu.edu). *Linear independence of time-frequency translates of functions with faster than exponential decay.*

We establish the linear independence of time-frequency translates for functions f having one sided decay

$$\lim_{x \rightarrow \infty} |f(x)|e^{cx \log x} = 0$$

for all $c > 0$. We will present a full proof in the case that $\lim_{x \rightarrow \infty} f(x)e^{cx^2} = 0$ for all $c > 0$, and indicate the modifications necessary to obtain the full result. (Received February 08, 2013)

1089-42-268 **Akram Aldroubi and Jacqueline Davis***, jacqueline.t.davis@vanderbilt.edu, and **Ilya Krishtal**. *Dynamical Sampling*.

We propose a new type of inverse problem which arises from sampling an evolving field at various times. We show that coarse samplings taken at varying times often contain the same information as a finer sampling taken at the earliest time. In other words, under some conditions on the evolving system, we can trade spatial samples for time samples. (Received February 17, 2013)

1089-42-304 **John Jasper*** (jasperj@missouri.edu), Department of Mathematics, Columbia, MO 65211, and **Marcin Bownik** (mbownik@uoregon.edu), Department of Mathematics, Eugene, OR 97403. *Spectra of frame operators with prescribed frame norms*.

In recent work with Marcin Bownik we characterize the sequences which arise as the norms of frames having a given frame operator with finite spectrum. This is equivalent to a characterization of the diagonals of a given self-adjoint operator with finite spectrum. In other words, we prove an infinite dimensional Schur-Horn theorem for operators with finite spectrum.

In this talk we consider the converse problem of characterizing the set of finite spectra of the frame operators of frames with a given sequence of norms. We will show several properties of this set, including a characterization which, unlike our previous characterization, closely resembles the finite dimensional Schur-Horn theorem. This talk is based on joint work with Marcin Bownik. (Received February 18, 2013)

43 ► Abstract harmonic analysis

1089-43-11 **Vignon S Oussa*** (vignon.oussa@bridgew.edu), Department of Mathematics Conant Science & Ma, Bridgewater, MA 02325. *Parseval Frame Wavelets on Some Non-Abelian Nilpotent Matrix Groups*. Preliminary report.

We present the existence and construction of Shannon-like Parseval frame wavelets on some groups of nilpotent matrices isomorphic to $(\mathbb{R}^{n-2d} \times \mathbb{R}^d) \rtimes \mathbb{R}^d$. Let N be an element of such class of non commutative matrix groups of dimension n . There is a faithful representation of N in $GL(n+1, \mathbb{R})$ and a faithful representation of a discrete group H in $GL(n+1, \mathbb{R})$ such that H is a subgroup of $\text{Aut}(N)$ isomorphic to \mathbb{Z} . Let L be the left regular representation of N acting in $L^2(N)$. We define the representation $D : H \rightarrow U(L^2(N))$, by $D_A f(\cdot) = \det(Ad_A)^{-1/2} f(A^{-1}\cdot)$. Moreover we prove the existence of a lattice subgroup Γ , and we construct a countable family of functions $\{f_k : k \in \mathbb{I}\}$ such that the system $\{D_{A^j} L(\gamma) f_k : \gamma \in \Gamma, j \in \mathbb{Z}, k \in \mathbb{I}\}$ is a Parseval frame in $L^2(N)$. In our talk, we also explore some connections between the analysis of the class of groups presented and Gabor theory. (Received October 16, 2012)

1089-43-19 **Palle E. T. Jorgensen*** (palle-jorgensen@uiowa.edu), Dept mathematics, MLH, University of Iowa, Iowa City, IA 52242. *Tilings in wavelet theory: IFS measures and wavelet packets*. Preliminary report.

The presentation makes connections between three closely intertwined problems: (i) certain partitions (tilings) of the integers; (ii) wavelet-packets; and (iii) generalized IFS-measures. The tilings in are arithmetic progressions at integral multiples of length equal to powers of natural numbers. The wavelet packets in (ii) are generated by a fixed system of wavelet filters (corresponding to a fixed number N of orthogonal frequency bands). From (ii) we obtain by methods from papers by the author and co-authors (Bratteli, Dutkay, Alpay, among others) certain representations of the Cuntz algebra O_N generating an algebra A of operators. And the IFS-measures in (iii) are from an associated maximal abelian subalgebra of A . (Received December 02, 2012)

1089-43-309 **Benjamin Purkis*** (benjamin.purkis@colorado.edu). *Constructing Projective Multiresolution Analyses over Irrational Rotation Algebras*. Preliminary report.

We will construct an example of a projective multiresolution analysis (PMRA) where the initial module is over an irrational rotation algebra. We will then discuss generalizations of this idea, including a method of combining such PMRA structures to create new ones. (Received February 18, 2013)

1089-43-328 **Azita Mayeli*** (amayeli@qcc.cuny.edu). *Bracket map for the Heisenberg group and the characterization of cyclic subspaces*. Preliminary report.

The bracket map was originally considered in [1] for locally compact abelian groups. In this work we extend the study of bracket maps to the non-commutative setting, providing characterizations of bases and frames for cyclic subspaces of the Heisenberg group. We also indicate how to generalize these results to non-abelian nilpotent Lie groups whose irreducible representations are square integrable modulo the center. This is a joint work with

Davide Barbieri and Eugenio Hernández.

[1] E. Hernández, H. Šikić, G. Weiss, E. Wilson, *Cyclic subspaces for unitary representations of LCA groups: generalized Zak transforms*. Colloq. Math. 118(1):313-332 (2010). (Received February 18, 2013)

45 ► *Integral equations*

1089-45-44 **Francesco Demontis*** (fdemontis@unica.it), viale Merello 92, 09123 Cagliari, Italy, and **Cornelis van der Mee**. *Direct Scattering Problem for Zakharov-Shabat system: characterization of scattering data*.

In this talk, we study the direct scattering theory for the matrix Zakharov-Shabat (Z-S) system. First, we show how it is possible to include the usual scattering data (consisting in one reflection coefficient, the discrete eigenvalues and the corresponding norming constants) in a suitable pair of Marchenko integral kernels. Those kernels are expressed as the sum of an L^1 function (having a reflection coefficient as its Fourier transform) and a finite exponential sum encoding the discrete eigenvalues and norming constants. Then, the 1,1-correspondence between the potentials pair appearing in the Z-S system and the pair of Marchenko kernels described above will be established. Characterization results for the particular and significant focusing and defocusing cases will also be discussed. (Received January 18, 2013)

46 ► *Functional analysis*

1089-46-47 **Deguang Han***, Department of Mathematics, University of Central Florida, Orlando, FL 32816. *Spectrally Optimal Frames for Erasures*. Preliminary report.

Frames are useful tools in dealing with signal transmissions when erasures occur. Instead of using the operator norm as the error measurement for the error matrices when erasures occur in data transmission, I will discuss the optimal (dual) frame problem with respect to the spectral measurement, which seems to be a more natural choice when iteration procedure is allowed in the reconstruction. I will report some partial results on the characterization of spectrally optimal frames for one or two erasures. (Received January 22, 2013)

1089-46-110 **Frederic Latremoliere*** (frederic@math.du.edu). *Quantum Locally Compact Metric Spaces*.

Noncommutative metric geometry is the study of noncommutative generalizations of algebras of Lipschitz functions on metric spaces. Inspired by the work of Connes, Rieffel introduced the notion of a compact quantum metric space and a generalization of the Gromov-Hausdorff distance, thus providing a framework for many approximations of quantum geometries by finite quantum spaces found in the mathematical physics literature and opening a new and fascinating area of inquiry for C^* -algebra researchers. However, the question of extending this nascent theory to the more general locally compact setting has been raised many times, in contexts such as the study of spectral triples from C^* -dynamical systems to the study of the Moyal planes and other physically relevant models, while an answer remained elusive for some years. In this talk, I propose my suggestion for the foundation of such an extension. I will present a notion of a quantum locally compact metric space, motivated in part by the development of a notion of a generalized quantum Gromov-Hausdorff convergence, provide a few useful characterizations of this new concept, as well as several examples. (Received February 07, 2013)

1089-46-134 **Chris Heunen** and **Manuel L. Reyes*** (reyes@bowdoin.edu), Bowdoin College, Department of Mathematics, 8600 College Station, Brunswick, ME 04011. *Diagonalizing matrices over AW*-algebras*.

AW*-algebras are C^* -algebras that are endowed with an abundant supply of projections (self-adjoint idempotent elements). We prove that if A is an AW*-algebra, then any commuting set of normal $n \times n$ matrices over A is simultaneously diagonalizable. A key tool that is used in the proof is a new dimension theory for properly infinite projections in an AW*-algebra. (Received February 10, 2013)

1089-46-193 **Paul Frank Baum*** (baum@math.psu.edu), Mathematics Department, Penn State University, University Park, PA 16802. *Expanders, exact crossed products, and K-theory for group C^* algebras*.

An expander is a sequence of finite graphs X_1, X_2, X_3, \dots which is efficiently connected. A discrete group G which “contains” an expander in its Cayley graph is a counter-example to the Baum-Connes (BC) conjecture with coefficients. M. Gromov outlined a method for constructing such a group. G. Arjantseva and T. Delzant

completed the construction. The group so obtained is known as the Gromov group and is the only known example of a non-exact group.

The left side of BC with coefficients “sees” any group as if the group were exact. This talk will indicate how to make a change in the right side of BC with coefficients so that the right side also “sees” any group as if the group were exact. This corrected form of BC with coefficients uses the unique minimal intermediate exact crossed-product.

For exact groups there is no change in BC with coefficients. In the corrected form of BC with coefficients the Gromov group acting on the coefficient algebra obtained from an expander is not a counter-example. Thus at the present time (February, 2013) there is no known counter-example to the corrected form of BC with coefficients. The above is joint work with E. Kirchberg and R. Willett. This work is based on — and inspired by — a result of R. Willett and G. Yu. (Received February 14, 2013)

1089-46-205 **Judith A Packer*** (packer@euclid.colorado.edu), Department of Mathematics, Campus Box 395, University of Colorado at Boulder, Boulder, CO 80309-0395. *Projective modules for noncommutative solenoids*. Preliminary report.

“Noncommutative solenoids” are certain twisted group C^* -algebras, where the groups in question are countably infinitely generated; these algebras can also be generated as direct limits of rotation algebras. From examining the range of the trace of the K_0 -groups of the noncommutative solenoids, their finitely generated projective modules can be constructed. We also discuss a way of using directed systems of equivalence bimodules between directed systems of C^* -algebras to set up Morita equivalences between noncommutative solenoids and other C^* -algebras.

This work is joint with Frédéric Latrémolière. (Received February 15, 2013)

1089-46-260 **Dorin Ervin Dutkay** and **John Haussermann*** (jhaussermann@knights.ucf.edu). *Tiling Properties of Spectra of Measures*.

We investigate tiling properties of spectra of measures, i.e., sets Λ in \mathbb{R} such that $\{e^{2\pi i\lambda x} : \lambda \in \Lambda\}$ forms an orthogonal basis in $L^2(\mu)$, where μ is some finite Borel measure on \mathbb{R} . Such measures include Lebesgue measure on bounded Borel subsets, finite atomic measures and some fractal Hausdorff measures. We show that various classes of such spectra of measures have translational tiling properties. This lead to some surprizing tiling properties for spectra of fractal measures, the existence of complementing sets and spectra for finite sets with the Coven-Meyerowitz property, the existence of complementing Hadamard pairs in the case of Hadamard pairs of size 2,3,4 or 5. In the context of the Fuglede conjecture, we prove that any spectral set is a tile, if the period of the spectrum is 2,3,4 or 5. (Received February 17, 2013)

1089-46-334 **Mira A Peterka*** (mpeterka@math.ku.edu). *Complex Vector Bundles over the Theta-Deformed 4-Sphere*.

We report on work classifying and constructing all finitely-generated projective modules (“complex vector bundles”) over the θ -deformed 4-sphere of Connes and Landi. If the deformation parameter θ is rational, the situation mirrors the classical case, but if θ is irrational, then new phenomena arise. Specifically, if θ is irrational, there are then nontrivial rank-1 modules. This work is part of a larger project in noncommutative gauge theory. (Received February 18, 2013)

47 ► Operator theory

1089-47-182 **Tim Wertz*** (tmwertz@math.ucdavis.edu) and **Thomas Strohmer**. *Localization of Matrix Factorizations*.

An important non-commutative generalization of the famous Wiener’s Lemma states that under certain conditions the inverse \mathbf{A}^{-1} of a matrix \mathbf{A} will inherit the off-diagonal decay properties of \mathbf{A} . In this paper, we investigate whether this Wiener property extends to matrix factorizations. For example, given the QR-factorization $\mathbf{A} = \mathbf{Q}\mathbf{R}$ of a bi-infinite matrix \mathbf{A} , where \mathbf{A} belongs to some Banach algebra \mathcal{A} which characterizes its off-diagonal decay, do \mathbf{Q} and \mathbf{R} also belong to \mathcal{A} ? We will answer this question for the most important matrix factorizations. (Received February 14, 2013)

1089-47-312 **David R. Larson*** (larson@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843. *Frames, Dilations and Operator-Valued Measures*.

Dilation theory for discrete frames extends naturally to include dilation results for continuous frames. The key is an understanding of the connection between frame theory and operator valued-measures on sigma algebras

of sets, and a generalized dilation theory for OVM's and linear maps on von Neumann algebras. (Received February 18, 2013)

49 ► *Calculus of variations and optimal control; optimization*

1089-49-215 **Brent R Davis*** (bdavis1@rams.colostate.edu), Brent R. Davis, Department of Mathematics, 1874 Campus Delivery, Fort Collins, CO 80523-187, and **Daniel Bates, Chris Peterson, Michael Kirby** and **Justin Marks**. *A nonconvex method to find a subspace mean on a disjoint union of grassmann manifolds*. Preliminary report.

Let $\{\mathcal{V}_1, \dots, \mathcal{V}_k\}$ be a set of subspaces of a finite-dimensional vector space \mathcal{V} . Consider the problem

$$\min_{l \in \mathcal{V}} \sum_{i=1}^k \cos(\theta(\mathcal{V}_i, l))$$

where l is a 1-dimensional subspace of \mathcal{V} .

$\theta(\mathcal{V}_i, l) = \{v_i \cdot w \mid v_i \in \mathcal{V}_i, w \in l, \|v_i\| = \|w\| = 1\}$ is called the first principal angle between \mathcal{V}_i and l . The problem is of interest in data analysis and inherently non-convex. It is equivalent to finding a computable subspace mean on a disjoint union of grassmannians each of varying dimensions.

A method has been developed to solve this optimization problem. Utilizing tools from algebraic geometry and linear algebra, a numerical algorithm will be proposed to find the global solution to this problem. (Received February 15, 2013)

1089-49-325 **Lori Beth Ziegelmeier*** (ziegelme@math.colostate.edu), 101 Weber Building, Fort Collins, CO 80523-1874, and **Michael Kirby** (kirby@math.colostate.edu) and **Chris Peterson** (peter@math.colostate.edu). *Sparse Nearest Neighbor Selection for the Locally Linear Embedding Algorithm*.

Manifold learning techniques such as the Locally Linear Embedding (LLE) algorithm have been proven useful in geometric data analysis and dimensionality reduction. We present modifications to the LLE algorithm that lead to sparse representations in local reconstructions by using a data weighted l-1 norm regularization added to the reconstruction error. This new formulation has proven effective at automatically determining nearest neighbors using sparsity of numerical results. We apply this technique to biological data sets such as gene expression data from the Duke influenza study. (Received February 18, 2013)

51 ► *Geometry*

1089-51-139 **Nigel Higson*** (higson@math.psu.edu), Department of Mathematics, Penn State University, University Park, PA 16802. *Some noncommutative geometry problems arising from the orbit method*. Preliminary report.

Kirillov's orbit method attempts organize the unitary representation theory of a Lie group around the symplectic-geometric concept of coadjoint orbit. It can be thought of as a correspondence principle between quantum systems (the irreducible unitary representations of a Lie group) and their classical counterparts (the orbits). As such, it is related to correspondence principles seen in noncommutative geometry, for example between operators and symbols. I shall formulate some specific questions in noncommutative geometry that arise from this relationship. (Received February 10, 2013)

1089-51-168 **Steffen Weil*** (steffen.weil@math.uzh.ch). *Schmidt games and conditions on resonant sets*.

Winning sets of Schmidt's game enjoy a remarkable rigidity. Therefore, this game (and modifications of it) have been applied to many examples of complete metric spaces (X, d) to show that the set of 'badly approximable points' $\mathbf{Bad}(\mathcal{F})$, with respect to a given family \mathcal{F} of resonant sets in X , is a winning set. For these examples, strategies were deduced that are, in most cases, strongly adapted to the specific dynamics and properties of the underlying setting. We introduce a new modification of Schmidt's game which is a combination of the ones of Kleinbock, Weiss and McMullen. Winning sets of this modification satisfy similar but weaker properties than winning sets of Schmidt's game. Moreover, we axiomatize conditions on the collection of resonant sets under which $\mathbf{Bad}(\mathcal{F})$ is a winning set for the modified game. Finally, we verify our conditions for several examples. (Received February 13, 2013)

1089-51-177 **François Ledrappier*** (fledrapp@nd.edu), Department of Mathematics, Hurley Hall, University of Notre Dame, Notre Dame, IN 46556. *Entropies and rigidity of compact manifolds.*

We introduce and discuss asymptotic growth rates defined on the universal cover of compact manifolds. We show some general inequalities. We discuss some equality cases when the manifold has no focal points. (Received February 13, 2013)

1089-51-189 **Jon Chaika*** (jonchaika@gmail.com), 1018 E 54th st, #2, Chicago, IL 60615, and **Yitwah Cheung** and **Howard Masur**. *Badly approximable directions on flat surfaces.*

Continuing from Masur's talk we discuss some arguments in the proof that on every flat surface the set of angles badly approximated by saddle connection directions is a winning set for the absolute winning variant of Schmidt's game. This is joint work with Y. Cheung and H. Masur. (Received February 14, 2013)

1089-51-232 **Fedor L Soloviev*** (feds04@gmail.com), Dept. of Mathematics, University of Toronto, Room 6290, 40 St. George Street, Toronto, Ontario M5S 2E4, Canada, and **Boris Khesin**. *Integrability of higher pentagram maps.*

We define higher pentagram maps on polygons in any dimension, which extend R. Schwartz's definition of the 2D pentagram map. These maps turn out to be integrable for both closed and twisted polygons. The corresponding continuous limit of the pentagram map in dimension d is shown to be the $(2,d+1)$ -equation of the KdV hierarchy, generalizing the Boussinesq equation in 2D. In the 3D case we describe the corresponding spectral curve, first integrals, Liouville tori, and the motion along them. This is a joint work with Boris Khesin (University of Toronto). (Received February 15, 2013)

52 ► Convex and discrete geometry

1089-52-335 **Mario Kummer**, **Daniel Plaumann** and **Cynthia Vinzant*** (vinzant@umich.edu). *Hyperbolic polynomials, interlacers, and sums of squares.*

Hyperbolic polynomials are real polynomials whose real hypersurfaces are nested ovals, the inner most of which is convex. These polynomials appear in many areas of mathematics, including optimization, combinatorics and differential equations. I'll give an introduction to this topic and discuss the special connection between hyperbolic polynomials and their interlacing polynomials (whose real ovals interlace the those of the original). This will let us relate inner oval of a hyperbolic hypersurface to the cone of nonnegative polynomials and, sometimes, to sums of squares. An important example will be the basis generating polynomial of a matroid. (Received February 18, 2013)

1089-52-336 **Kurt M Anstreicher*** (kurt-anstreicher@uiowa.edu), C120 PBB, Iowa City, IA 52242. *An Approach to the Dodecahedral Conjecture Based on Bounds for Spherical Codes.*

The dodecahedral conjecture states that in a packing of unit spheres in \mathbb{R}^3 , the Voronoi cell of minimum possible volume is a regular dodecahedron with inradius one. The conjecture was made by Fejes Toth in 1943, and proved by Hales and McLaughlin in 1998 using techniques developed by Hales for his proof of the Kepler conjecture. The proof of Hales and McLaughlin, while apparently correct, is difficult to verify due to the many cases and extensive computations required. In his 1964 book *Regular Figures*, Fejes Toth suggested a proof scheme for the dodecahedral conjecture but was unable to verify a key inequality. Recent work of Hales uses this same inequality as the basis for a new proof of the Kepler conjecture. We describe an approach for proving Fejes Toth's inequality that uses strengthened semidefinite programming bounds for spherical codes. (Received February 18, 2013)

1089-52-374 **Matthias Beck**, Department of Mathematics, San Francisco State University, San Francisco, CA 94132, **Pallavi Jayawant**, Department of Mathematics, Bates College, Lewiston, ME 04240, and **Tyrrell B. McAllister*** (tmcallis@uwyo.edu), Department of Mathematics, University of Wyoming, Laramie, WY 82071. *Lattice-point generating functions for free sums of polytopes.*

Let \mathcal{P} and \mathcal{Q} be polytopes in \mathbb{R}^n whose affine spans intersect at a single rational point in $\mathcal{P} \cap \mathcal{Q}$, and let $\mathcal{P} \oplus \mathcal{Q} = \text{conv}(\mathcal{P} \cup \mathcal{Q})$. We give formulas for the generating function

$$\sigma_{\text{cone}(\mathcal{P} \oplus \mathcal{Q})}(z_1, \dots, z_n, z_{n+1}) = \sum_{(m_1, \dots, m_n) \in t(\mathcal{P} \oplus \mathcal{Q}) \cap \mathbb{Z}^n} z_1^{m_1} \cdots z_n^{m_n} z_{n+1}^t$$

of lattice points in all integer dilates of $\mathcal{P} \oplus \mathcal{Q}$ in terms of $\sigma_{\text{cone } \mathcal{P}}$ and $\sigma_{\text{cone } \mathcal{Q}}$, under various conditions on \mathcal{P} and \mathcal{Q} . This work is motivated by (and recovers) a product formula of B. Braun for the Ehrhart series of $\mathcal{P} \oplus \mathcal{Q}$ in the case where \mathcal{P} and \mathcal{Q} are lattice polytopes containing the origin, one of which is reflexive. In particular, we

find necessary and sufficient conditions for Braun's formula and its multivariate analogue. (Received February 19, 2013)

53 ► *Differential geometry*

1089-53-36 **Camilo Mesa*** (mesa@colorado.edu), Department of Mathematics, UCB 395, University of Colorado at Boulder, Boulder, CO 80309-0395. *Getzler Symbol Calculus and Deformation Quantization*.

We give a construction of Fedosov quantization incorporating the odd variables and an analogous formula to Getzler's pseudodifferential calculus composition formula is obtained. A Fedosov type connection is constructed on the bundle of Weyl tensor Clifford algebras over the cotangent bundle of a Riemannian manifold. The quantum algebra associated with this connection is used to define a deformation of the exterior algebra of Riemannian manifolds. (Received January 16, 2013)

1089-53-118 **Rafal Komendarczyk*** (rako@tulane.edu), 6823 St. Charles Ave, New Orleans, LA 70118. *Remarks on the asymptotic invariants of divergence free vector fields*. Preliminary report.

I will review the Arnold's construction of the asymptotic linking number for a divergence free vector field on S^3 and indicate some of its interesting consequences. (Received February 08, 2013)

1089-53-332 **Morgan Sherman*** (sherman1@calpoly.edu) and **Ben Weinkove**. *Local Calabi and curvature estimates for the Chern-Ricci flow*.

The Chern-Ricci flow on a complex manifold is a smooth flow of Hermitian metrics which coincides with the Ricci flow in case the manifold is Kähler. Assuming local uniform bounds on the metric for a solution of the Chern-Ricci flow, we establish local Calabi and curvature estimates using only simple maximum principle arguments. (Received February 18, 2013)

54 ► *General topology*

1089-54-172 **Angelo Bella** (bella@dmi.unict.it), Università degli Studi di Catania, Dipartimento di Matematica e Informatica, viale Andrea Doria 6, 98025 Catania, Italy, and **Santi Spadaro*** (santispadaro@yahoo.com), Institute of Mathematics, Silesian University in Opava, Na Rybníčku 626/1, 74601 Opava, Czech Rep. *A playful chain condition on topological spaces*.

Daniels, Kunen and Zhou in 1994 and Aurichi in 2012 independently introduced the following game-theoretic strengthening of the countable chain condition. Two players play an inning per positive integer: at the n -th inning, player I picks a maximal family of pairwise disjoint open sets and player II picks an open set from that family. Player II wins if he's able to select a family with a dense union. If player II has a winning strategy in this game on the space X then X has the ccc. Moreover, player II has an easy winning strategy when playing this game on spaces of countable π -weight.

We restate the cellularity of a topological space in terms of transfinite generalizations of this game and use this new framework to give a game-theoretic proof of Shapirovskii's classical bound for the number of regular open sets of a regular space. As a byproduct we obtain that the playful ccc and countable π -weight are equivalent for spaces of countable π -character. (Received February 13, 2013)

1089-54-235 **Andrea Medini*** (medini@math.wisc.edu), Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706. *Countable dense homogeneity and set theory*.

A separable (usually metrizable) space X is countable dense homogeneous (briefly, CDH) if for every pair (D, E) of countable dense subsets of X there exists a homeomorphism $h : X \rightarrow X$ such that $h[D] = E$. The Euclidean spaces \mathbb{R}^n , the Hilbert cube $[0, 1]^\omega$ and the Cantor set 2^ω are all examples of CDH spaces, while \mathbb{Q}^ω is not. I will discuss more interesting examples, and survey some of the ways in which set theory is helpful in the study of CDH spaces (especially those involving Martin's axiom, ultrafilters and descriptive set theory). Also, I might make brief detours on "How to prove stuff in ZFC" and the topological Vaught conjecture. (Received February 16, 2013)

55 ► Algebraic topology

1089-55-1 **Gunnar Erik Carlsson*** (gunnar@math.stanford.edu), 998 Cottrell Way, Stanford, CA 94305-2125. *The Shape of Data.*

Making sense of large and complex data sets is a fundamental problem for all areas of science, engineering, and large segments of the commercial world. Data sets typically are equipped with a distance metric which defines, in a certain sense, the "shape of the data". In recent years, methods have been developed to adapt methods of topology, the mathematical study of shape, to the study of data sets. I will discuss these developments, with numerous examples. (Received February 20, 2013)

1089-55-190 **Paul Louis Bendich*** (bendich@math.duke.edu), **Bei Wang** and **Sayan Mukherjee**. *Towards Stratification Learning via Homology Inference.*

A topological approach to stratification learning is developed for point cloud data drawn from a stratified space. We define a multi-scale notion of a stratified space, giving a stratification for each radius level, and we define a related notion of multi-scale (persistent) local homology. We then use methods derived from kernel and cokernel persistent homology to cluster the data points into different strata, and we prove a result which guarantees the correctness of our clustering, given certain topological conditions. Our correctness result is then given a probabilistic flavor: we give bounds on the minimum number of sample points required to infer, with probability, which points belong to the same strata. Finally, we give an explicit algorithm for the clustering, prove its correctness, and apply it to some simulated data. (Received February 14, 2013)

1089-55-298 **Jing Wang*** (gwjwang@gwu.edu), 3010 Hightower Place APT 418, Fairfax, VA 22031. *Khovanov-type Homology and Homology of Small Categories.*

We start from describing Khovanov homology in the context of homology of small categories with coefficients in the functor into $Z[x]/(x^2)$. We then speculate on generalization of Przytycki's and Turner's ideas relating Hochschild homology and Khovanov homology using the tool of barycentric subdivision of small categories. (Received February 18, 2013)

1089-55-365 **Crichton Ogle** and **Boris Tsygan*** (b-tsygan@northwestern.edu), Northwestern Math Department, 2033 Sheridan Road, Evanston, IL 60208. *An approach to the Novikov conjecture.* Preliminary report.

We revisit an old approach to the Novikov conjecture that is based on analyzing a smooth completion of the group algebra of a free resolution of the group. We formulate a geometric property of the Cayley graph of a discrete group which, conjecturally, implies the Novikov conjecture for higher signatures. This property is related to various versions of combability. (Received February 19, 2013)

1089-55-385 **Krzysztof K Putyra***, Mathematics, 2990 Broadway, Room 509, New York, NY 10027, and **Jozef H Przytycki**. *Degenerate part of distributive homology is determined by its normalized part.* Preliminary report.

The distributive homology of quandles and racks proved to be a useful tool in the theory of knots and links. After its discovery by Carter, Kamada and Saito, it was noticed that the distributive chain complex for a quandle splits into two parts, normalized and degenerate, imitating the simplicial homology theory. However, a degenerate complex is not acyclic, contrary to the simplicial theory. Recently, with Jozef Przytycki we managed to prove that the degenerate part, as its name suggests, is completely determined by the normalized homology.

In my talk I will describe the distributive chain complex associated to a quandle and, more generally, to splindles, and how it splits into degenerate and normalized part. Then I will give a recursive formula for the degenerate part and sketch main ideas of its proof. (Received February 19, 2013)

57 ► Manifolds and cell complexes

1089-57-90 **Louis Hirsch Kauffman*** (kauffman@uic.edu), Louis H. Kaufman, 5530 South Shore Drive, Apt 7C, Chicago, IL 60637-1946. *Quantum Computing with Majorana Fermions.*

A Majorana fermion is a fermion that is its own anti-particle. Such particles occur in the mathematics of the Ising model, possibly in the electronics of nano-wires and in the quasi-particles that are conjectured to underly the quantum Hall effect. The purpose of this talk is to show how representations of the Artin braid group are related to Majorana fermions and to discuss how the mathematics of these models is related to structures of knot-set theories and logical structures such as the formalism of the calculus of indications of G. Spencer-Brown which is generated by a logical particle $[\]$ that can interact with itself in two ways: $[\] [\] \longrightarrow [\]$ or $[\] [\] \longrightarrow \longrightarrow$

* (where * is an empty word) thus having the fusion rules of a Majorana fermion. This talk is related to the following paper by the presenter: <http://arxiv.org/pdf/1301.6214.pdf>. (Received February 03, 2013)

1089-57-164 **Daniel J. Carrillo*** (dcarrillo34825@gmail.com) and **Louis H. Kauffman**. *Flat Stick Knots*.

We enumerate knots whose diagrams can be formed with six or fewer sticks in the plane. These knots arise through making all possible crossing choices on a corresponding set of flat diagrams. We construct the set of flat knot diagrams on six or fewer sticks.

(Received February 12, 2013)

1089-57-171 **Markus Banagl*** (banagl@mathi.uni-heidelberg.de), Mathematical Institute, Heidelberg University, Im Neuenheimer Feld 288, 69120 Heidelberg, Germany. *High-Dimensional Topological Quantum Field Theory, Singularities of Maps, and Exotic Spheres*. Preliminary report.

We will discuss the construction of a new topological field theory defined on smooth manifolds, which is not limited to low dimensions. The fields are given by a certain class of smooth maps, whose singularities together with diagrammatic techniques from knot theory are used to define a matrix valued action functional that factors through a categorification of the Brauer algebra arising in the representation theory of the orthogonal group. The path integral is carried out using Markov idempotent integration, which means that the theory is defined over a semiring. The resulting invariants are polynomials depending on boundary conditions, and detect exotic smooth structures on spheres. (Received February 13, 2013)

1089-57-366 **Jozef H. Przytycki*** (przytyck@gwu.edu), Department of Mathematics, George Washington University, Washington, DC 20052, and **Krzysztof Putyra**. *Degenerate part of a rack homology satisfies Künneth formula, I: weak simplicial modules*.

Most of the classical homology theories based on associative structures (e.g. group homology or Hochschild homology) are built on some simplicial set or module. In such cases the degenerate subcomplex is acyclic, so we can quotient by it to get normalized chain complex with the same homology as the original chain complex. If we replace associativity by distributivity then the degenerate complex does not have to be acyclic (as noted 15 years ago by Carter, Kamada, and Saito). We observe that in place of a simplicial module we deal now with a weak simplicial module. In the special case of spindles and quandles (distributive structures motivated by and important in Knot Theory) connection between degenerate and normalized homology was analyzed from the beginning without general results (except by Litherland and Nelson that rack homology splits into degenerate and normalized parts). We prove here that degenerate homology of a quandle (or spindle) can be deduced from the normalized part by a formula of a Künneth type. The theorem has as a starting point the observation that a weak simplicial module leads to a bicomplex, which can be analyzed using a spectral sequence. (Received February 19, 2013)

1089-57-367 **Carla Farsi**, University of Colorado at Boulder, Department of Mathematics, Campus Box 395, Boulder, CO 80309-0395, **Markus Pflaum**, University of Colorado at Boulder, Department of Mathematics, Campus Box 395, Boulder, CO 80309-0395, and **Christopher Seaton*** (seatonc@rhodes.edu), Rhodes College, Mathematics and Computer Science Department, 2000 N. Parkway, Memphis, TN 38112. *The inertia space associated to a proper Lie group action as a stratified space*.

Let G be a compact Lie group and let M be a smooth G -manifold. If G happens to act locally freely on M , then the quotient of M by the G -action is an example of an orbifold. In the study of the geometry of orbifolds, an object called the inertia orbifold has played a major role. The inertia orbifold is a disjoint union of orbifolds given by the quotient of the space of loops of the translation groupoid, a smooth manifold, by a natural action of the translation groupoid itself.

If the action of G is not assumed to be locally free, then the space of loops of the translation groupoid is no longer a smooth manifold, and the quotient is no longer an orbifold. In this case, we refer to the quotient of the space of loops as the inertia space of the G -manifold M . We will describe an explicit Whitney stratification of the inertia space. Using this stratification, we will present a de Rham theorem for cohomology of differential forms on the inertia space with respect to this stratification. (Received February 19, 2013)

1089-57-380 **Charles D. Frohman** and **Joanna Kania-Bartoszyńska***, jkaniaba@nsf.gov. *Quantum Invariants of 3-Manifolds and their Asymptotics*.

Given a knot in the 3-sphere, we consider the 3-manifold which is the double of the knot complement. We discuss the asymptotic behavior of the Witten-Reshetikhin-Turaev invariants of such manifolds. (Received February 19, 2013)

1089-57-402 **Mieczyslaw K Dabkowski*** (mdab@utdallas.edu), Department of Mathematical Sciences, University of Texas at Dallas, Richardson, TX 75080. *Links modulo rational moves*.

Study of equivalence classes of links up to rational moves plays an important role in the theory of invariants based on the skein relation and, in particular, skein modules. We consider 4-move for knots and links of 2 components and its related invariants. We prove, in particular, that all knots in the family 6^* reduce modulo 4-moves to the trivial knot and show that links of 2 components in $6^* a_1 a_2 a_3 a_4 a_5 a_6$ such that a_i is a 2-algebraic tangle with no trivial components reduce to either the trivial link or to the Hopf link. We also suggest link $9^* .2 : .2 : .2$ as a potential counterexample to 4-move reducibility of links of 2 components. (Received February 19, 2013)

58 ► *Global analysis, analysis on manifolds*

1089-58-28 **Markus J Pflaum*** (markus.pflaum@colorado.edu), Department of Mathematics, University of Colorado UCB 395, Boulder, CO 80305, and **Hessel Posthuma** and **Xiang Tang**. *Geometry of orbit spaces of proper Lie groupoids*.

In the talk, the geometric properties of quotient spaces of proper Lie groupoids will be examined. In particular, a natural stratification on such spaces will be constructed using an extension of the slice theorem for proper Lie groupoids by Weinstein and Zung. It will be shown that a transversally invariant riemannian metric exists on a proper Lie groupoid which gives the associated Lie algebroid the structure of a singular riemannian foliation. Moreover, we show that a transversally invariant riemannian metric induces a natural length space structure on the orbit space of the Lie groupoid. Finally, a de Rham theorem for the complex of basic differential forms on a proper Lie groupoid is proved. (Received January 10, 2013)

1089-58-54 **Zhizhang Xie*** (zhizhang.xie@vanderbilt.edu), Math Department, Vanderbilt University, 1326 Stevenson Center, Nashville, TN 37240, and **Guoliang Yu**. *Positive scalar curvature, higher rho invariants and localization algebras*.

In our recent paper, we used localization algebras to study the higher rho invariant for closed spin manifolds with positive scalar curvature metric. The higher rho invariant is a secondary invariant and is closely related to the positive scalar curvature problems. The main result of the paper connects the higher index of the Dirac operator on a spin manifold with boundary to the higher rho invariant of the Dirac operator on the boundary, where the boundary is endowed with a positive scalar curvature metric. As an application, we obtain a homomorphism from the Stolz's positive scalar curvature exact sequence to the exact sequence of Higson and Roe, in all dimensions. (Received January 24, 2013)

1089-58-61 **John Roe***, Department of Mathematics, Penn State University, University Park, PA 16802. *Calculations with analytic structures*. Preliminary report.

We report on some calculations involving the Higson-Roe analytic structure set (Received January 26, 2013)

1089-58-82 **Farzad Fathizadeh*** (ffathiz@uwo.ca), Department of Mathematics, Middlesex College, Western University, London, Ontario N6A 5B7, Canada, and **Masoud Khalkhali** (masoud@uwo.ca), Department of Mathematics, Middlesex College, Western University, London, Ontario N6A 5B7, Canada. *Scalar Curvature for Noncommutative Four Tori*.

I will report on a recent joint work with M. Khalkhali in which we study the curved geometry of noncommutative four tori \mathbb{T}_θ^4 . We prove the analogue of Weyl's law, Connes' trace theorem, and compute the scalar curvature of \mathbb{T}_θ^4 whose flat geometry is perturbed conformally by means of a Weyl factor. We also consider the analogue of the Einstein-Hilbert action for \mathbb{T}_θ^4 and show that metrics with constant curvature are critical points of this action. (Received February 02, 2013)

1089-58-92 **Igor Prokhorenkov*** (i.prokhorenkov@tcu.edu), Department of Mathematics, TCU Box 298900, Fort Worth, TX 76129, and **Ken Richardson**. *Examples of Witten deformations for Riemannian foliations.*

Witten deformation of a transversal Dirac operator is a useful tool for studying geometry and topology of Riemannian foliations. We will give examples of Witten deformations and describe some results obtained by these techniques. (Received February 04, 2013)

1089-58-104 **Abbas Bahri*** (abahri@math.rutgers.edu), Department of Mathematics, Rutgers university, New Brunswick, NJ 08903. *Stable Homologies through deformations of v -convex contact forms.*

We establish the existence of a homology, invariant by deformation of v -convex contact forms, for contact structures on $\text{eg } S^3$. Typical examples are the standard contact structure and the first exotic contact structure of J.Gonzalo and F.Varela on S^3 . The homology is non-zero for both examples. The results are derived by extended variational theory and can be applied to obtain periodic orbits of the related contact vector-fields. (Received February 06, 2013)

1089-58-116 **Jochen Brüning, Franz W Kamber and Ken Richardson*** (k.richardson@tcu.edu), TCU Box 298900, Fort Worth, TX 76129. *Multiplicities of the equivariant index.*

We describe a formula for the multiplicities of the index of an equivariant transversally elliptic operator on a G-manifold. The formula is a sum of integrals over blowups of the strata of the group action and also involves eta invariants of associated elliptic operators. Among the applications, we obtain an index formula for basic Dirac operators on Riemannian foliations, a problem that was open for many years. We demonstrate this theorem on several examples. (Received February 07, 2013)

1089-58-121 **Michel L. Lapidus*** (lapidus@math.ucr.edu), University of California, Department of Mathematics, Riverside, CA 92521-0135, and **Jonathan J. Sarhad**. *Noncommutative Geometry, Analysis on Fractals, Dirac Operators and Geodesic Metric on Fractal Manifolds.*

We construct Dirac operators and spectral triples for certain, not necessarily self-similar fractal sets built on curves. Connes' distance formula in noncommutative geometry provides a natural metric on the fractal. As an important motivating example, we consider the harmonic Sierpinski gasket, which represents the ordinary (Euclidean) gasket from the analytical point of view. We prove that the noncommutative metric coincides with the natural geodesic metric on the harmonic gasket (recently studied by J. Kigami). The present work extends to the non-Euclidean (and analytically relevant) setting some of the main results of the paper by E. Christensen, C. Ivan and M.L. Lapidus (Adv. in Math. No. 1, 217 (2008, pp.42-78). Our current, broader framework allows for several further potential applications to geometric analysis on fractal manifolds. (Received February 08, 2013)

1089-58-143 **Pierre Albin*** (palbin@illinois.edu), **Eric Leichtnam**, **Rafe Mazzeo** and **Paolo Piazza**. *Hodge cohomology of stratified spaces.*

On certain stratified spaces, 'Witt spaces', the middle perversity intersection homology of Goresky-MacPherson is dual to the L2-cohomology of Cheeger. I will describe recent progress on understanding the relation for general stratified spaces. (Received February 11, 2013)

1089-58-271 **Erik van Erp***, jhamvanerp@gmail.com. *A (Very) Brief History of the Index Theory of Toeplitz Operators.*

After a brief overview of the history of the index theory of Toeplitz operators, starting in the early 20th century with the work of Fritz Noether, and leading via the Gohberg-Krein formula to Boutet de Monvel's result for strictly pseudoconvex boundaries of complex domains, I will discuss recent results of P.Baum and myself, and where they fit in this historical perspective. (Received February 17, 2013)

1089-58-342 **Vincent Bonini** (vbonini@calpoly.edu), Department of Mathematics, Cal Poly State University, San Luis Obispo, CA 93407, **Jose M. Espinar** (jespinar@impa.br), Instituto de Matemática Pura e Aplicada, 110 Estrada Dona Castorina, Rio de Janeiro, 22460-320, Brazil, and **Jie Qing*** (qing@ucsc.edu), Department of Mathematics, 4111 McHenry, University of California, Santa Cruz, CA 95064. *Hypersurfaces in hyperbolic space with support functions.*

In this talk we report our recent work on hypersurfaces in hyperbolic space with support functions. We will discuss when a hypersurface in hyperbolic space has a global support function. We will also discuss when a

complete, immersed, proper hypersurface in hyperbolic space with a support function is embedded. (Received February 18, 2013)

60 ► *Probability theory and stochastic processes*

1089-60-144 **James L Carroll*** (j1carroll@lanl.gov), Los Alamos, NM 87544. *Practical Considerations for Analysis By Synthesis, a Real World Example using DARHT Radiography*. Preliminary report.

The mathematical theory of inverse problems has been intensely explored for many years. One common solution to inverse problems involves analysis by synthesis, where a forward model produces a synthetic data set, given model inputs, and optimization is used to find model inputs that minimize the difference between the real data and the synthetic data. Some beautiful mathematical results demonstrate that under ideal situations, this procedure returns the MAP estimate for the parameters of the model. However, many practical considerations exist that make this procedure much harder to actually use and implement. In this presentation, we will evaluate some of these practical considerations, including: Hypothesis testing over confidence, overfitting systematic errors instead of overfitting noise, optimization uncertainties, and complex measurement system calibration errors. The thrust of this work will be to attempt to qualitatively and quantitatively assess the errors in density reconstructions for the Dual Axis Radiographic Hydrotest Facility (DARHT) and LANL. (Received February 11, 2013)

65 ► *Numerical analysis*

1089-65-12 **I Aloyan*** (ialolyan@ksu.edu.sa), King Abdulaziz St # 25, Riyadh, 11451, Saudi Arabia. *Linear Programming with Fuzzy Objective Function*.

The conventional linear programming model requires the parameters to be known as constants. In the real world, however, the parameters are seldom known exactly and have to be estimated. Interval programming is one of the tools to tackle uncertainty in mathematical programming models. In this paper, we consider linear programming problem whose coefficients are uncertain. The relation between closed and bounded intervals is derived, and the solution of such a problem is proposed by considering the partial orderings on the set of all closed intervals. (Received October 27, 2012)

1089-65-49 **Thomas Trogdon*** (trogdon@amath.washington.edu), Department of Applied Mathematics, University of Washington, Guggenheim Hall #414, Box 352420, Seattle, WA 98195. *A numerical Riemann–Hilbert approach for the Korteweg–de Vries equation*.

It is well known that the Cauchy initial-value problem for the Korteweg–de Vries (KdV) equation on the line may be solved with the inverse scattering transform (IST). Often, the IST is described in terms of the solution of a matrix Riemann–Hilbert problem. Building on this technique, I will describe how the construction of periodic and quasi-periodic solutions of the KdV equation can be performed with matrix Riemann–Hilbert problems. Furthermore, using a computational approach to Riemann–Hilbert problems, the IST, periodic solutions and quasi-periodic solutions are computed with uniform accuracy. (Received January 22, 2013)

1089-65-183 **Dan Bates*** (bates@math.colostate.edu), **Eric Hanson** (hanson@math.colostate.edu), **Jon Hauenstein** (hauenstein@ncsu.edu) and **Charles Wampler** (charles.w.wampler@gm.com). *Searching for exceptional mechanisms via fiber products*. Preliminary report.

Kinematicians find value in special mechanisms (e.g., robotic arms) that have more degrees of freedom than general mechanisms of the same type. We refer to these as exceptional mechanisms. There are very few known exceptional mechanisms, and there are currently no general methods for locating them within their respective mechanism types. Schreyer and others have had success with techniques that sometimes produce examples, but it would be useful to have a general method.

In this talk, I will introduce some new techniques coming from numerical algebraic geometry to produce an efficient, general algorithm for finding such exceptional sets. I will outline our method, touching briefly on the basics of numerical algebraic geometry, homotopies for fiber products, and recent methods for numerical irreducible component intersection.

In fact, this problem is of more general interest than stated above. Our algorithm finds parameter values for which a parameterized family of polynomial systems has solution sets of dimension higher than those at general

points in the parameter space. As a simple example, our method finds the unique parameter values (a, b, c) so that the equation $ax^2 + bx + c = 0$ has a positive-dimensional solution set. (Received February 14, 2013)

68 ► *Computer science*

1089-68-159 **Jon Lee***, University of Michigan, Ann Arbor, MI. *A PTAS for Matroid Matching.*

I will describe a PTAS for (unweighted) matroid matching for general matroids. This is in contrast to the intractability of obtaining an exact solution for general matroids, and the p-time algorithm for obtaining an exact solution for linear matroids. Joint work with Maxim Sviridenko and Jan Vondrak. (Received February 12, 2013)

1089-68-226 **Hanna E Makaruk*** (hanna_m@lanl.gov), P-21 Applied Modern Physics Group, MS-D410, LANL, Los Alamos, NM 87545. *3D object reconstruction from a single radiogram – outside of the Inverse Abel method.* Preliminary report.

Reconstruction of a 3D object from its 2D radiogram requires an additional assumption to make it unique. In particular, Inverse Abel transform uses the assumption of axial symmetry for the reconstruction. However, the assumption does not necessarily need to be one of axial symmetry. A good quality radiogram (adequate beam power, detector) is a sum of contributions of all the objects seen by the beam – and different constraints can be applied for each “component” of this sum. In case of an object containing parts that are axially symmetric and parts that are either i) not axially symmetric or ii) symmetric in relation to two or more different axes, correct reconstruction for a single radiogram requires more steps than in a simple axially symmetric case. More importantly, the reconstruction can be still exact and unique. For many problems there is a rich set of information about the object included in the radiogram, not utilized in the Inverse Abel transform, which can serve as the additional assumption in the cases considered here. Animations obtained from the strict analytical solutions for the discussed objects are presented. (Received February 19, 2013)

1089-68-372 **Christopher Tomkins*** (ctomkins@lanl.gov), Physics Division, P-21, MS D410, Los Alamos, NM 87507, and **Hanna Makaruk**. *3D effects in axisymmetric reconstructions: theory, simulation and experiment.* Preliminary report.

In a variety of penetrating imaging diagnostics, quantities of interest are reconstructed from a single-view measurement under an assumption of axisymmetry. Here we employ theory, simulation and experiment to explore the effects of 3-dimensionality on these reconstructions. A key finding is that 3D effects may cause local negative densities, which are clearly unphysical, to appear in Abel inverse-type reconstructions. Analytical solutions are derived for violations of the axisymmetric assumption in the form of simple geometric shapes, and numerical Abel inversions are also performed on similar geometric problems. Both theory and numerics predict significant regions of inferred negative density under these conditions. These predictions are tested against an experimental measurement of known, idealized objects (spheres) using quantitative penetrating radiography. Results are compared for various values of the characteristic parameter, D/r (where D is the distance from reconstruction axis, r is the sphere radius). The results suggest that negative density values in Inverse-Abel reconstructions should not be ignored; instead, they provide potentially important insights into the 3D nature of the underlying phenomena. (Received February 19, 2013)

1089-68-393 **Tamon Stephen** and **Timothy Yusun*** (tyusun@sfu.ca), Faculty of Science, Simon Fraser University, 250 - 13450 102nd Avenue, Surrey, BC V3T0A3, Canada. *Counting inequivalent monotone Boolean functions.*

Monotone Boolean functions (MBFs) are Boolean functions $f : \{0, 1\}^n \rightarrow \{0, 1\}$ satisfying the monotonicity condition $x \leq y \Rightarrow f(x) \leq f(y)$ for any $x, y \in \{0, 1\}^n$. The number of MBFs in n variables is known as the n th Dedekind number. It is a longstanding computational challenge to determine these numbers exactly – these values are only known for n at most 8. Two monotone Boolean functions are equivalent if one can be obtained from the other by renaming the variables. The number of inequivalent MBFs in n variables was known only for up to $n = 6$. In this paper we propose a strategy to count inequivalent MBF’s by breaking the calculation into parts based on the profiles of these functions. As a result we are able to compute the number of inequivalent MBFs in 7 variables. The number obtained is 490013148. (Received February 19, 2013)

76 ► Fluid mechanics

1089-76-66 **Huidan Whitney Yu*** (whyu@iupui.edu). *Mass-conserved volumetric lattice Boltzmann method for biological flows with or without willfully moving boundaries.*

We develop a mass-conserved lattice Boltzmann formulation for willfully moving arbitrary boundaries using volumetric representation aiming to simulate biological flows in human body. In this method, fluid particles are uniformly distributed in lattice cells characterized by the ratio of solid volume over the cell volume to distinguish three types of lattice cells in the flow domain: solid, fluid, and boundary cell. The formulation consists of three parts: (1) collision taking into account of momentum exchange between the willfully moving boundary and the flow; (2) Streaming accompanying with a volumetric bounce-back procedure at boundary cells; and (3) Boundary-induced fluid migration to satisfy mass conservation of fluid when the boundary crosses over a boundary cell and becomes solid cell. This approach can handle arbitrary boundary orientation and motion with respect to the mesh. Two application studies are carried out for validation. One is blood flow in aorta and another is urine flow in urinary tract driven by peristaltic motion of ureter. The focus is on the examination of the wall shear/normal stress on artery's inner layer aiming to help predict the development and evolution of aortic aneurysms and dissections in the former and prostate problems in the latter. (Received January 28, 2013)

1089-76-102 **Maria E. Schonbek*** (schonbek@ucsc.edu), **Jose A Carrillo**, **Maria Gonzalez** and **Maria Gualdani**. *Fokker-Planck and Neuroscience.*

I will analyze the global existence of classical solutions to the initial boundary-value problem for a nonlinear parabolic equation describing the collective behavior of an ensemble of neurons. These equations were obtained as a diffusive approximation of the mean-field limit of a stochastic differential equation system. The resulting nonlocal Fokker-Planck equation presents a nonlinearity in the coefficients depending on the probability flux through the boundary. I will show that by an appropriate change of variables this parabolic equation with nonlinear boundary conditions can be transformed into a non standard Stefan-like free boundary problem with a Dirac-delta source term. I will discuss the existence of global classical solutions for inhibitory neural networks, while for excitatory networks I will show a local well-posedness of classical solutions together with a blow up criterium. (Received February 05, 2013)

1089-76-165 **Katie L Oliveras*** (oliveras@seattleu.edu) and **Vishal Vasan**. *Recovering the water-wave profile from pressure measurements.*

A new method is proposed to recover the water-wave surface elevation from pressure data obtained at the bottom of the fluid. The new method requires the numerical solution of a nonlocal nonlinear equation relating the pressure and the surface elevation which is obtained from the Euler formulation of the water-wave problem without approximation. From this new equation, a variety of different asymptotic formulas are derived. The nonlocal equation and the asymptotic formulas are compared with both numerical data and physical experiments. (Received February 12, 2013)

1089-76-169 **Susan Friedlander*** (susanfri@usc.edu). *A PDE Model for Turbulent Energy Cascade.*

We discuss a PDE model in frequency space for the inertial energy cascade that reproduces the classical scaling laws of Kolmogorov's theory of turbulence. The resulting model is a variant of Burgers equation on the half line with a boundary condition which represents a constant energy input at integral scales. We show the existence of a unique stationary solution, both in the viscous and the inviscid cases, which replicates the classical dissipation anomaly in the limit of vanishing viscosity.

This is joint work with Alexey Cheskidov and Roman Shvydkoy. (Received February 13, 2013)

1089-76-228 **Xinwei Yu***, 632 CAB, University of Alberta, Edmonton, Alberta T6R2K9, Canada, and **Chuong V. Tran**, **Luke A. K. Blackbourn** and **Zhichun Zhai**. *On Global Regularity of 2D Incompressible Magnetohydrodynamics equations with Partial Dissipation.*

In this talk I will discuss some recent analytical and numerical results regarding global regularity for the 2D incompressible magnetohydrodynamics equations with partial dissipation, that is when the dissipation term is only present in either the momentum equation or the induction equation but not both. I will present several new sufficient conditions for global regularity together with numerical simulation results indicating that these conditions are indeed satisfied. I will also present several results regarding global regularity of 2D and nD generalized magnetohydrodynamics equations in which the Laplacians are replaced by fractional Laplacian operators.

This is joint work with C. V. Tran and L. A. K. Blackbourn of University of St. Andrews, Scotland, and Z. Zhai of University of Alberta. (Received February 15, 2013)

1089-76-250 **Jon Wilkening*** (wilken@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94720-3840. *Nearly time-periodic water waves.*

We develop a high-performance shooting algorithm to compute new families of time-periodic and quasi-periodic solutions of the free-surface Euler equations involving breathers, traveling-standing waves, and collisions of solitary waves of various types. The wave amplitudes are too large to be well-approximated by weakly nonlinear theory, yet we often observe behavior that resembles elastic collisions of solitons in integrable model equations. A Floquet analysis shows that many of the new solutions are stable to harmonic perturbations. Evolving such perturbations over tens of thousands of cycles suggests that the solutions remain nearly time-periodic forever. (Received February 17, 2013)

1089-76-263 **Xiaoming Wang*** (wxm@math.fsu.edu), 208 James J. Love Building, Department of Mathematics, Florida State University, Tallahassee, FL 32312. *Phase field models for two phase flows in karstic geometry.* Preliminary report.

Multiphase flow phenomena are ubiquitous. Common examples include coupled atmosphere and ocean system (air and water), oil reservoir (water, oil and gas), cloud and fog (water vapor, water and air). Multiphase flows also play an important role in many engineering and environmental science applications. In some applications such as flows in unconfined karst aquifers, karst oil reservoir, proton membrane exchange fuel cell, multiphase flows in conduits and in porous media must be considered together. Geometric configurations that contain both conduit (or vug) and porous media is termed karstic geometry. Despite the importance of the subject, little work has been done on multi-phase flows in karstic geometry. Multiphase flows in karstic geometry pose additional challenges beyond the usual difficulties associated with multi-phase flows. In this talk, we present a family of phase field models for two phase flows in karstic geometry that are derived via Onsager's extremum principle. These phase field models enjoy physically important energy laws. Numerical schemes that preserve the energy laws will be presented as well. (Received February 17, 2013)

1089-76-321 **Jerry L. Bona*** (jbona@uic.edu), Dept. Math. Statistics & Computer Science, University of Illinois at Chicago, 851 S. Morgan St. MC 249, Chicago, IL 60607. *Rogue Waves in the Ocean and in Fiber Optic Cables.*

The lecture will focus upon a possible route to the formation of rogue waves in both oceanic and fiber optics transmission lines. (Received February 18, 2013)

1089-76-407 **Robert Michal Owczarek*** (rowczare@unm.edu), The Department of Mechanical Engineering, University of New Mexico, Albuquerque, NM 87131. *Recent results in mathematical fluid mechanics.* Preliminary report.

My recent results in mathematical fluid mechanics will be presented. (Received February 20, 2013)

78 ► *Optics, electromagnetic theory*

1089-78-46 **Pavel M Lushnikov***, Department of Mathematics and Statistics, MSC01 1115, 1 University of New Mexico, Albuquerque, NM 87131-0001, and **Sergey A Dyachenko** and **Natalia Vladimirova**. *Logarithmic scaling of critical collapse of Nonlinear Schrodinger equation.*

We study the collapse of the nonlinear Schrodinger equation (NLS) in critical case of dimension two. The collapse describes e.g. self-focusing of light in nonlinear Kerr media. The scaling of self-similar solutions near collapse point has $(t_0 - t)^{1/2}$ scaling law with the logarithmic modifications of log-log type. We show that the well-known leading order log-log modification occurs for nonrealistic exponentially large amplitudes of light $\sim 10^{100}$. Instead we derived a new equation for adiabatically slow parameter which determines the system dynamics. Based on that equation we develop a perturbation theory for scaling modifications beyond leading log-log order and perform detailed comparison with simulations. We show that new scaling agrees with simulations for very moderate increase (~ 3 times) of the amplitude of initial pulse. (Received January 18, 2013)

1089-78-230 **Natalia Vladimirova*** (nvladimi@unm.edu), **Gregory Falkovich** and **Pearson Miller**. *Phase transitions and collective oscillations in optical turbulence.*

We consider turbulence within the Gross-Pitaevsky model and look into the creation of a coherent condensate via an inverse cascade originated at small scales. The growth of the condensate leads to a spontaneous breakdown of statistical symmetries of over-condensate fluctuations: first, isotropy is broken, then series of phase transitions mark changing symmetry from two-fold to three-fold to four-fold. In real space this symmetry is observed as a pattern in over-condensate fluctuations with a short-range positional and long-range orientational order (like

in a hexatic phase). The interaction of the condensate with wave turbulence results in periodical transfer of a small fraction of waves between the condensate and the turbulent part of the spectrum. We show that these oscillations are not of a predator-prey type as was suggested earlier; they are due to phase coherence between the pairs of counter-propagating waves (anomalous correlations) imposed by condensate. (Received February 15, 2013)

1089-78-389 **Chris Curtis***, Department of Applied Mathematics, 526 UCB, University of Colorado, Boulder, CO 80309. *Tight-Binding Approximations and Edge States in Honeycomb Optical Lattices.*

Over the last several years, a great deal of interest has emerged over honeycomb optical lattices, which are modeled by a Gross-Pitaevskii (GP) equation with a periodic, two-dimensional potential. Using a tight-binding approximation in the semi-classical limit, a two-dimensional nonlinear discrete system has been derived as an approximation to the GP equation. We present results that establish the validity of this approximation on asymptotically long time scales.

By introducing an edge into the discrete system, we then present results on the propagation of modes localized along the edge, or edge modes. Ignoring nonlinearity, one can find a plethora of linear edge modes, but a central question is what is the impact of nonlinearity on these profiles. In the case of weak nonlinearity, we have developed a rigorously justified approximation describing the impact of nonlinearity on the linear modes. The most important result from this is that the nonlinearity does not cause delocalization away from the edge. In the case of strong nonlinearity, we present numerical results which show the nonlinearity does not cause delocalization, and thus edge modes should be a stable feature for optical lattices with edges. (Received February 19, 2013)

83 ► *Relativity and gravitational theory*

1089-83-62 **ZBIGNIEW OZIEWICZ*** (oziewicz.zbigniew@gmail.com), Universidad Nacional Autonoma de Mexico, Facultad de Estudios Superiores Cuautitlan, Estado de Mexico, C.P. 54715 Cuautitlan Izcalli, Mexico. *The link problem for algebraic isometry: the complete solution.*

The name isometry is used in three different meanings: preserving topological distance; algebraic isometry preserving metric tensor given by algebraic condition, this apply to arbitrary metric tensor. The third meaning of isometry is diffeomorphism generated by Killing vector fields. Algebraic isometry group acting transitively on homogeneous spaces possesses the link problem to determine all isometries that permute given two points a and b of the homogeneous space, $g(a,b)a=b$, such that $g(a,a)=\text{identity}$, and $g(a,b)$ is algebraic isometry known in the physics publications as the boost from a to b . It is not well known that in general the link problem for the given isometry do not possess the unique solution. We solved completely the link problem in terms of decomposable (simple) Grassmann bivector showing that in general every isometric permutation is ternary, ie depends crucially on the choice of extra 'preferred' point on homogeneous space, $g(p,a,b)$. This general solution of the link problem allows two different binary composition of such ternary permutations. One binary composition is unital quasigroup (non-associative group known as a left Bol and left Bruck loop) - compatible with the non-normal isometric stabilizer subgroup. Other possibility is associative binary composition. (Received January 27, 2013)

90 ► *Operations research, mathematical programming*

1089-90-2 **Jesus A. De Loera*** (deLoera@math.ucdavis.edu), Dept. of Mathematics, University of California, Davis, CA 95616. *Recent advances in the theory of linear programming.* Preliminary report.

Linear programming is undeniably a central tool of applied mathematics and a source of many fascinating mathematical problems. In this talk I will present several advances from the past 5 years in the theory of linear optimization. These results include new results on the complexity of the simplex method, the structure of central paths of interior point methods, and about the geometry of some less well-known iterative techniques. One interesting feature of these advances is that they connect this very applied algorithmic field with algebraic geometry and combinatorial topology.

I will try to summarize work by many authors and will include results that are my own joint work with subsets of the following people A. Basu, M. Junod, S. Klee, B. Sturmfels, and C. Vinzant. (Received February 19, 2013)

1089-90-57 **Shafiu Jibrin*** (shafiu.jibrin@nau.edu), Department of Mathematics & Statistics, Box 5717, Flagstaff, AZ 86011, and **Bryan Karlovitz**, West Chester, PA 19383. *An Algorithm for Solving the Convex Feasibility Problem With Linear Matrix Inequality Constraints and an Implementation for Second-Order Cones.*

In a 2007 paper, Ait Rami et al give an algorithm for solving the convex feasibility problem with a single linear matrix inequality constraint. We extend this to a system of linear matrix inequalities while giving an implementation that exploits the structure of the problem. We investigate the effect of the value used for eigenvalue replacement and give numerical evidence indicating that the choices of 0 and 1 used in their paper are not the best. A modification of this algorithm is proposed and we give an implementation for the special case of second-order cone constraints. Finally, we present the results of numerical experiments which indicate that our methods are effective. (Received January 24, 2013)

1089-90-176 **Jiawang Nie***, 9500 Gilman Drive, UCSD Mathematics, La Jolla, CA 92093. *The \mathcal{A} -Truncated K -Moment Problem.*

Let \mathcal{A} be a finite subset of N^n , and K be a compact semialgebraic set. An \mathcal{A} -tms is a vector y indexed by elements in \mathcal{A} . The \mathcal{A} -TKMP problem studies whether a given y admits a K -measure or not. This paper proposes a numerical algorithm for solving \mathcal{A} -TKMPs. It is based on finding a flat extension of y by solving a hierarchy of semidefinite relaxations, whose objective R is generated in a certain randomized way. If y admits no K -measures and $R[x]_{\mathcal{A}}$ is K -full, we can get a certificate for the nonexistence of representing measures. If y admits a K -measure, then for almost all generated R , we prove that: i) we can asymptotically get a flat extension of y ; ii) under a general condition that is almost sufficient and necessary, we can get a flat extension of y . The complete positive matrix decomposition and sum of even powers of linear forms decomposition problems can be solved as an \mathcal{A} -TKMP. (Received February 13, 2013)

1089-90-231 **Walter D Morris*** (wmorris@gmu.edu), Department of Mathematical Sciences, George Mason University, 4400 University Drive, Fairfax, VA 22030. *Efficient Computation of a Canonical Form for a Generalized P -matrix.*

We use recent results on algorithms for Markov decision problems to show that a canonical form for a generalized P -matrix can be computed, in some important cases, by a strongly polynomial algorithm. (Received February 15, 2013)

1089-90-276 **Robert Hildebrand*** (rhildebrand@ucdavis.edu), **Amitabh Basu**, **Matthias Köppe** and **Marco Molinaro**. *The infinite group problem and extreme inequalities for integer programming.*

I present new results on the Gomory-Johnson infinite group problem, which appear in joint papers with A. Basu, M. Köppe, and M. Molinaro.

Over the last decade, integer programming solvers have been dramatically improved, in part, due to cutting planes. The infinite group problem studies general purpose cutting planes for integer programs by considering an infinite dimensional relaxation of k -rows of the simplex tableau. Extreme functions for the infinite group problem correspond to strong cutting planes. We give an algorithm for testing extremality of piecewise linear functions with rational breakpoints when $k = 1$. By constructing a new extreme function with specific irrational breakpoints, we demonstrate a strong number theoretic link to this problem. We discuss extensions of this algorithm to higher dimensions, allowing us to study extremality of functions related to general purpose multi-row cuts.

We also prove that any minimal continuous piecewise linear function that is genuinely k -dimensional and has at most $k + 1$ slopes is extreme for this k -dimensional infinite group problem. This generalizes the famous 2-slope theorem of Gomory and Johnson (1972) and the recent 3-slope theorem of Cornuéjols and Molinaro (2012). (Received February 18, 2013)

91 ► *Game theory, economics, social and behavioral sciences*

1089-91-147 **Tue N Ly*** (1ntue@brandeis.edu), Brandeis University, 415 South Street, Goldsmith 111, Waltham, MA 02454. *Winning and losing parameters of Schmidt's (α, β) -game.*

After more than 40 years since it was first invented by W. Schmidt, his (α, β) -game and its variations have been shown to be a powerful yet convenient tool to prove abundance in diophantine approximation and dynamical systems. However, there are very little studies on the problem of completely determining winning and losing parameters for most of the sets. Our goal is to provide the first systematic approach toward this question, and apply it to some interesting sets. (Received February 11, 2013)

92 ► *Biology and other natural sciences*

1089-92-8 **Qiong Yang*** (qiongy@stanford.edu) and **James E. Ferrell.** *From molecules to development: revealing simple rules of biological clocks.*

Organisms from cyanobacteria through vertebrates make use of biochemical and genetic oscillators to drive autonomous, repetitive processes like cell cycle progression and vertebrate somitogenesis. Despite the complexity and variety of biological oscillators, their core design invariably includes a negative feedback loop. However, absent crucial elements negative feedback circuits often settle into a stable steady state rather than oscillating. In this talk, I first discuss computationally how several modifications of the basic activator/repressor circuit can promote oscillation. Then I ask which of these strategies are actually utilized in the circuits found in nature by dissecting a mitotic oscillator in the *Xenopus laevis* early embryos. We found that the core negative feedback system of Cdk1-APC/C operates as a time-delayed, digital switch, with a time lag of 15 min between the activation of Cdk1 and its repressor APC/C and a tremendously high degree of ultrasensitivity. Mathematical modeling indicates that this time delay must be coupled to the ultrasensitivity to ensure robust oscillations and segregation of cell-cycle phases. Principles uncovered here may also apply to other activator-repressor oscillators and help in designing robust synthetic clocks. (Received February 17, 2013)

1089-92-20 **Joseph Rusinko*** (rusinkoj@winthrop.edu), 142 Bancroft Hall, Rock Hill, SC 29733, and **Brian Hipp.** *Invariant Based Phylogenetic Reconstruction Algorithms.* Preliminary report.

First proposed by Cavender and Felsenstein, and Lake, invariant based algorithms for phylogenetic reconstruction were widely dismissed by practicing biologists because invariants were perceived to have limited accuracy in constructing trees based on DNA sequences of reasonable length. Recent developments by algebraic geometers have led to the construction of lists of invariants which have been demonstrated to be more accurate on small sequences, but were limited in that they could only be used for trees with small numbers of taxa.

We have developed and tested an invariant based phylogenetic reconstruction algorithm which is accurate and efficient for biologically reasonable data sets. We demonstrate this software, and discuss mathematical and biological challenges to improving invariant based reconstruction algorithms. (Received December 07, 2012)

1089-92-23 **Robert Carlson*** (rcarlson@uccs.edu), Department of Mathematics, University of Colorado at Colorado Springs, 1420 Austin Bluffs Parkway, Colorado Springs, CO 80933, **Kurt Anderson,** Department of Biology, University of California at Riverside, Riverside, CA, and **Jonathan Sarhad,** Department of Biology, University of California at Riverside, Riverside, CA. *PDE Network Models for River Populations.*

River systems have a complex tree-like geometry which can impact models of population dynamics. Research on 'quantum graphs' and other studies of differential equations on graphs have developed techniques for treating partial differential equations on networks. The application of these ideas to problems of population persistence in river systems will be presented. (Received December 18, 2012)

1089-92-93 **Liming Wang*** (limingwang.math@gmail.com), 5151 State University Dr., Los Angeles, CA 90032, and **Jack Xin** and **Qing Nie.** *A critical quantity for noise attenuation in feedback systems.*

Feedback modules, which appear ubiquitously in biological regulations, are often subject to disturbances from the input, leading to fluctuations in the output. What are the functions of feedback loops? Why are there often multiple feedback loops in biological systems? Do they affect a system's noise property? In this talk, we will explore these questions by introducing a critical quantity: SAT (the signed activation time) that dictates the

noise attenuation capability in feedback systems. Our findings suggest that the inverse relationship between the noise amplification rate and the signed activation time could be a general principle for many biological systems regardless of specific regulations or feedback loops. (Received February 04, 2013)

1089-92-94 **Wing-Cheong Lo** (lo.75@mbi.osu.edu), **Mid Eum Lee** (lee.3551@buckeyemail.osu.edu), **Monisha Narayan** (narayan.28@math.ohio-state.edu), **Ching-Shan Chou*** (chou@math.osu.edu) and **Hay-Oak Park** (park.294@osu.edu). *Cell Polarization in Budding Yeast.*

Cell polarization, in which intracellular substances localize to a particular spot in response to external stimuli or internal cues, is central to cell physiology, and it underlies processes such as cell motility, cell division and cell differentiation. In this talk, we will present our recent work, using budding yeast as a model system, on how cells initiate symmetry breaking preceding the new bud emergence. Our mathematical modeling and simulations reveal potential mechanisms which underlie a biased cell polarity observed in daughter diploid yeast cells. Together with experiments, we showed that the spatial landmark cues and a GTPase activating protein play central roles in cell type specific budding patterns. (Received February 04, 2013)

1089-92-107 **Tomas Gedeon*** (gedeon@math.montana.edu), Department of Mathematical Sciences, Bozeman, MT 59715, and **Emily Harvey**, **Jeffrey Heys** and **Ross Carlsson**. *Modeling emergent properties of synthetic bacterial consortia.*

Microbiology research is currently undergoing a revolutionary transition from study of mono- cultures to study of natural and synthetic microbial communities. Microbial consortia play a key role in chronic medical infections, and there is a growing appreciation of the role the human micro- biome plays in shaping immune system response to pathogens. In this contribution we model a synthetic consortium that exhibits increased biomass in the experiments, compared to a single microbe community. We show that the adaptation of the members of the community to new conditions is responsible for the observed biomass increase. (Received February 06, 2013)

1089-92-146 **Flor A Espinoza** and **Stanly Steinberg L Steinberg*** (stanly@math.unm.edu), Department of Mathematics and Statistics, University of New Mexico, Albuquerque, NM 87131. *Understanding the Dynamics of Membrane Proteins.*

In this study, we show that an innovative time series analysis of single particle tracking data for the high affinity IgE receptor, FcεRI, on mast cells provides substantial quantitative information about the submicrometer organization of the membrane. The analysis focuses on the probability distribution function of the lengths of the jumps in the positions of the quantum dots labeling individual IgE FcεRI complexes between frames in movies of their motion. Our results demonstrate the presence, within the micrometer-scale cytoskeletal corrals, of smaller subdomains that provide an additional level of receptor confinement. There is no characteristic size for these subdomains; their size varies smoothly from a few tens of nanometers to a over a hundred nanometers. The probability distribution of the jump lengths is well fit, from 10nm to over 100nm, by a novel power law. The fit for short jumps suggests that the motion of the quantum dots can be modeled as diffusion in a fractal space of dimension less than two. (Received February 11, 2013)

1089-92-153 **William R Holmes*** (wrholmes@uci.edu), 340 Rowland Hall, University of California, Irvine, Irvine, CA 92697, and **Qing Nie**. *Spatio-temporal regulation of developmental processes.*

The central question in developmental biology is how a single cell can produce an organism with exquisitely complex spatial structure, reproducibly and robustly. Through the study of a number of model organisms, such as drosophila and mice, it is evident that biochemical regulation of cellular events such as differentiation is central to this process. The advent of modern experimental techniques has lead to the identification of important regulators of these processes. However, the mechanisms responsible for autonomous spatio-temporal control and the interactions between these regulators that give rise to this control in many cases remain elusive. We will discuss recent advances where mathematical techniques have been used to uncover these interactions and elucidate mechanisms underlying spatio-temporal control. (Received February 11, 2013)

1089-92-160 **Xinfeng Liu*** (xfliu@math.sc.edu), 1523 Greene Street, Department of Mathematics, University of South Carolina, Columbia, SC 29208. *Mathematical modeling of the dynamic interaction between cancer stem cells and non-stem cancer cells.*

Cancer stem cells (CSCs) have been identified in primary breast cancer tissues and cell lines. The size of CSC population varies a lot among cancer tissues and cell lines but is associated with aggressiveness of breast cancer. In this study, we develop a mathematical model to explore the key factors which control the size of CSC during tumor cell growth both in vitro and in vivo. Our mathematical model and experimental data suggest that there

is a negative feedback mechanism to control the balance between CSC and non-stem cancer cells. We further calculate how feedback sensitivities and robustness can be regulated by different intrinsic and extrinsic factors. (Received February 12, 2013)

1089-92-211 **Igor M Savukov*** (isavukov@lanl.gov), **Todor Karaulanov** and **Larry J Schultz**.

Ultra-low field anatomical magnetic resonance imaging. Preliminary report.

Anatomic imaging based on nuclear magnetic resonance, MRI, is a powerful diagnostic method. The quality improves with the strength of magnetic field and high-field scanners are routinely used in hospitals. However, the high-field MRI machines are bulky, expensive, and restrictive to patients and settings. Our SQUID team at Los Alamos works on alternatives – ultra-low field (ULF) MRI with sensitive detectors such as SQUIDs and atomic magnetometers. ULF MRI systems are cheaper, portable and have other advantages. The main problem of ULF MRI is low sensitivity. This leads to the compromise between image resolution, signal-to-noise ratio, scanning time, etc. How to make images applicable to medical diagnostics is the important challenge of the ULF MRI research. We investigate various methods for image improvement: the scan time increase, more sensitive detection, larger magnetic fields to align nuclear spins, and multi-channel detection. Image processing methods can be also used to improve the quality. I will present anatomical images obtained with a portable ULF MRI system and discuss various issues for improving them and making ULF MRI a useful medical tool. (Received February 15, 2013)

97 ► *Mathematics education*

1089-97-13 **Kurt Kreith*** (kkreith@ucdavis.edu), Mathematics Department, University of California, Davis, CA 95616-8633. *The Mathematics of Planet Earth in Schools.* Preliminary report.

As stated in the January 2012 Notices, one of the goals of MPE2013 is "Encourage mathematics teachers at all levels to communicate issues related to Planet Earth through their instruction and curriculum development." This session will deal with a course of study aimed at helping high school teachers to pursue this goal. (Received February 09, 2013)

AMES, IA, April 26–28, 2013

Abstracts of the 1090th Meeting.

00 ► *General*

1090-00-42 **Stewart Ernest Brekke*** (stewabruk@aol.com), 2900 Maple Ave, Downers Grove, IL 60515. *Geometric Figures as Sets of Parallel, Convergent and Divergent Plane Surfaces.*

Solid geometric figures such as cubes, rectangular parallelepipeds and pyramids may be thought of as sets of parallel, convergent and divergent plane surfaces. For example, a rectangular parallelepiped has 3 sets of parallel planes which converge as the edges of the figure. Each vertex of the parallelepiped is a convergence or divergence of the planes forming a trihedral angle. A square based pyramid is a set of four planes converging at or diverging from a point forming a tetrahedral angle as the apex of the pyramid. A plane forms the base and converges or diverges with two of the sides of the square based pyramid. These are trihedral angles as points of convergence or divergence. Plane surfaces may intersect with each other in lines of convergence or divergence or in the case of the vertices of a pyramid, points of convergence or divergence. (Received January 24, 2013)

01 ► *History and biography*

1090-01-1 **Kevin Costello***, Northwestern University, Department of Mathematics, Evanston, IL.
The algebraic structures of perturbative quantum field theory.

Physics treatments of quantum field theory involve ill-defined infinite-dimensional integrals, which are made sense of using Feynman diagrams and the theory of renormalization. I'll introduce a mathematical approach to perturbative quantum field theory, which is similar to the deformation quantization approach to quantum mechanics. In this approach, the theory of renormalization is used to prove a certain algebraic structure exists. As an application, I'll describe some joint work with John Francis, which gives a rigorous version of Witten's derivation of the Jones polynomial from the path integral. (Received March 18, 2012)

03 ► *Mathematical logic and foundations*

1090-03-28 **Sam Buss** and **Mia Minnes*** (minnes@math.ucsd.edu). *What does randomness mean for betting strategies?*

Algorithmic randomness defines what it means for a single mathematical object to be random. This active area of computability theory has been particularly fruitful in the past several decades, both in terms of expanding theory and increasing interaction with other areas of math and computer science. Randomness can be equivalently understood in terms of measure theory, Kolmogorov complexity (incompressibility), and martingales.

In this context, we present a novel definition of betting strategies that uses probabilistic algorithms also studied in complexity theory. Several variants of this definition using alternate probability measures are proposed and shown to be equivalent. This is joint work with Sam Buss. (Received January 16, 2013)

1090-03-56 **Stephen G. Simpson*** (simpson@math.psu.edu), Department of Mathematics, McAllister Building, Pollock Road, Pennsylvania State University, University Park, PA 16802.
Combining basis theorems. Preliminary report.

A *basis theorem* is a theorem saying that every nonempty effectively closed set in Euclidean space has at least one member which is, in some specific sense, close to being computable. Some well known basis theorems are the Cone Avoidance Basis Theorem, the Low Basis Theorem, the Hyperimmune-Free Basis Theorem, the R.E. Basis Theorem, and the Randomness Preservation Basis Theorem. Less well known is the recent Partial Randomness Preservation Basis Theorem due to Higuchi, Hudelson, Simpson, and Yokoyama. We discuss the possibilities for combining these basis theorems. A new result due jointly to Simpson and Frank Stephan says that we can combine cone avoidance with randomness preservation if and only if the cone to be avoided is non-K-trivial. (Received February 07, 2013)

1090-03-88 **Uri Andrews** and **Julia F. Knight*** (knight.1@nd.edu). *Strongly minimal theories with computable models.*

In computable model theory, we may look for conditions guaranteeing that a theory T has a computable model. The expectation is that for a theory with “nice” model-theoretic properties, building a model should be simpler. Here we show that for a strongly minimal theory T in a finite relational language, if $T \cap \Sigma_{n+3}$ is Δ_n^0 uniformly in n , then there is a computable model. In the construction, for each $n \geq 1$, a Δ_n^0 worker assigns B_{n-1} types (made up of formulas that are Boolean combinations of Σ_n formulas) to tuples. Strong minimality is used in showing that there is an enumeration of the B_n types computable relative to T_{n+2} . Our assumptions mean that Δ_n^0 can check the consistency of B_{n-1} types $p(\bar{u}, \bar{x})$ with B_n -types $q(\bar{u})$. We hope for a better result. (Received February 19, 2013)

1090-03-91 **W.M. Phillip Hudelson*** (phil.hudelson@gmail.com), 411 Waupelani Drive, APT A-301, State College, PA 16801. *Strong separations and Kolmogorov complexity.*

We prove using a forcing argument a new strong separation for partial randomness, which is equivalent to the following non-extraction result for Kolmogorov complexity: Let $f : \mathbb{N} \rightarrow [0, \infty)$ be a recursive and unbounded function such that $f(n+1) \leq f(n) + 1$ for all n and $\lim_{n \rightarrow \infty} (n - f(n)) = \infty$. Then there is an X such that $K(X \upharpoonright n) \geq f(n)$ for all n , but no Y recursive in X satisfies $K(Y \upharpoonright n) \geq f(n) + 2 \log_2(f(n)) + O(1)$ for all n . Here X and Y are infinite sequence of 0's and 1's, $X \upharpoonright n$ denotes the length n initial segment of X , and K denotes prefix-free complexity. This theorem generalizes the theorem of Miller (*Advances in Mathematics*, 226 (1): 373–384, 2011) that there exists a Turing degree of effective Hausdorff dimension $1/2$. (Received February 20, 2013)

1090-03-108 **Noopur J Pathak*** (pathak@math.psu.edu), Mathematics Department, University Park, PA 16802, **Cristobal Rojas** (cristobal.rojas@unab.cl), Departamento de Matemáticas, Santiago, Chile, and **Stephen Simpson** (simpson@math.psu.edu), Mathematics Department, University Park, PA 16802. *Schnorr randomness and the Lebesgue Differentiation Theorem.*

We establish a correspondence between L_1 -computable functions and Schnorr tests. Using this correspondence, we prove that a point $x \in [0, 1]^d$ is Schnorr random if and only if the Lebesgue Differentiation Theorem holds at x for all L_1 -computable functions. (Received February 22, 2013)

1090-03-128 **Wesley Calvert*** (wcalvert@siu.edu), Department of Mathematics, Mail Code 4408, 1245 Lincoln Drive, Southern Illinois University, CARBONDALE, IL 62901, **Valentina Harizanov**, George Washington University, and **Alexandra Shlapentokh**, East Carolina University. *Algorithmic unsolvability in geometry.*

We show that a well-known classification from computable model theory places some interesting classes of geometric objects on the side of admitting high algorithmic diversity.

Two sets are Turing equivalent if there is an algorithm to decide membership in each, given information on membership in the other. We can think of an algebraic structure (e.g. a ring) as a set by considering the quadruples $(a, b, a + b, ab)$. It is easy to see that isomorphism does not preserve Turing equivalence.

For many classes of structures, it is known that the set of Turing degrees of isomorphic copies of a single structure may have any least element we wish, or no least element at all. For other classes of structures, the situation is much more restrictive. In the present work, we show that the former is true for certain classes of ringed spaces, including unions of certain families of curves. (Received February 25, 2013)

1090-03-132 **Roger D Maddux*** (maddux@iastate.edu), Math. Dept. 396 Carver Hall, Iowa State University, Ames, IA 50011. *Consistent theories with no finite models.* Preliminary report.

Every finite relation algebra has a corresponding finitely axiomatized first-order theory in a language containing only binary relation symbols and equality. The theory has a model if and only if the algebra is representable.

Some consistent theories arising in this way have no infinite models, and some have no finite models. For example, J. D. Monk's relation algebras give rise to theories that have no infinite models because of Ramsey's Theorem for binary relations. The theory of dense linear orderings without endpoints, which comes from a relation algebra having 8 elements, has no finite models because there is no transitive dense antisymmetric relation on a finite set.

Other examples of consistent theories without finite models, ones that (perhaps surprisingly) involve only symmetric relations, come from a class of relation algebras suggested by A. Tarski in 1973. A similar example was found recently. Proofs that these theories have no finite models are combinatorial and deal with edge-colorings of complete graphs. They will be presented in pictures, along with several open problems whose solutions are

needed in order to complete a survey (started by R. Lyndon in 1950) of the 102 integral relation algebras with 16 elements. (Received February 25, 2013)

1090-03-149 **Xizhong Zheng*** (zhengx@arcadia.edu), 450 S. Easton Road, Glenside, PA 19038. *On the Computable Curves.*

In mathematics curves are typically defined as the images of continuous real functions (*parametrizations*) defined on a closed interval. They can also be defined as connected one-dimensional compact subsets of points. For simple curves of finite lengths, parametrizations can be further required to be injective or even length-normalized. All of these four approaches to curves are classically equivalent. However, if we define four different versions of *computable curves* based on the effectivization of these four approaches. It turns out that they are all different, and hence, we get four different classes of computable curves. More interestingly, these four classes are even *point-separable* in the sense that the sets of points covered by computable curves of different versions are also different. However, if we consider only computable curves of computable lengths, then all four versions of computable curves become equivalent. This shows that the definition of computable curves is robust, at least for those of computable lengths. In addition, we show that the class of computable curves of computable lengths is point-separable from the other four classes of computable curves. (Received February 26, 2013)

1090-03-156 **Carl G. Jockusch***, Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W. Green St., Urbana, IL , and **Andrew E. M. Lewis.** *Diagonally noncomputable functions and bi-immunity.*

A function $f : \omega \rightarrow \omega$ is called *diagonally noncomputable* (DNC) if $(\forall e)[f(e) \neq \varphi_e(e)]$. It is known that every $\{0, 1\}$ -valued DNC function computes a 1-random set, and that every 1-random set computes a DNC function. We consider the extent to which this pattern can be continued downwards by showing that every DNC function computes a set with some vestige of randomness. In the negative direction, we analyze a proof from [2] to show that there is a DNC function which computes no weakly 1-random set. A set A is called *bi-immune* if neither A nor its complement has an infinite computably enumerable subset. Our main result is that every DNC function computes a bi-immune set, and in fact there is a Turing functional Ψ such that, for every DNC function f , Ψ^f is the characteristic function of a bi-immune set. The proof is an atypical tree argument using the recursion theorem. This work will appear in [1].

[1] C. Jockusch and A. E. M. Lewis, Diagonally noncomputable functions and bi-immunity, to appear in *Journal of Symbolic Logic*.

[2] M. Kumabe and A. E. M. Lewis, A fixed point free minimal degree, *Journal of the London Mathematical Society*, 80 (3) (2009), 785-797. (Received February 27, 2013)

1090-03-173 **Uri Andrews*** (andrews@math.wisc.edu), **Mingzhong Cai**, **David Diamondstone**, **Joseph S Miller** and **Steffen Lempp.** *Recursively presenting models of Solovay theories.* Preliminary report.

If a theory has a recursive model, then the \exists_n fragment of the theory is uniformly Σ_n . Theories which have this property are called Solovay theories. Not all Solovay theories have recursive models. We characterize the Turing degrees which present models of every Solovay theory as those Turing degrees which present non-standard models of true arithmetic. (Received February 28, 2013)

1090-03-183 **Kyle Riggs***, kwriggs@umail.iu.edu. *The Σ_1^1 -completeness of the Decomposability of Torsion-Free Abelian Groups.* Preliminary report.

An abelian group is decomposable if it can be written as the direct sum of two (or more) nontrivial subgroups. Among torsion groups, the decomposable groups have previously been completely characterized. Among torsion-free groups, we show that this property is Σ_1^1 -complete, so it cannot be characterized by a first-order logic in the language of arithmetic. (Received February 28, 2013)

1090-03-206 **Douglas Cenzer*** (cenzer@uf1.edu), Department of Mathematics, University of Florida, P.O. Box 118105, Gainesville, FL 32611-8105, and **Sebastian Wyman** (swyman@uf1.edu). *Effectively closed sets and symbolic dynamics.* Preliminary report.

In the study of computable functions on the Cantor space, it is well-known that the image of such a function is a decidable closed set and we showed recently that the set of itineraries of a computable function is also a decidable closed set. Also every decidable closed set is the image of a computable function and every decidable subshift is the set of itineraries of a computable function. However, there do exist non-decidable Π_1^0 classes (non-decidable effectively closed sets). We define the notion a conservatively approximable function on the Cantor space and show that the Π_1^0 classes are exactly the images of $2^{\mathbb{N}}$ under conservatively approximable functions. Furthermore, every Π_1^0 subshift is the set of itineraries of some computably approximable function. We are now extending

these notions and results to computable and semi-computable functions on the real interval. (Received March 01, 2013)

1090-03-225 **Denis R. Hirschfeldt*** (drh@math.uchicago.edu), Department of Mathematics, The University of Chicago, 5734 S. University Ave., Chicago, IL 60637, and **Carl G. Jockusch, Jr.**. *Notions of computability theoretic reduction between Π_2^1 principles*. Preliminary report. Several notions of computability theoretic reducibility between principles of the form $\forall X [\Theta(X) \rightarrow \exists Y \Psi(X, Y)]$ have been studied. I will discuss some of these, and introduce a new notion, intended to capture the idea of reducing a principle P uniformly to multiple applications of a principle Q . (Received March 01, 2013)

1090-03-249 **Achilles Athanasios Beros*** (aberos@math.wisc.edu). *Computability Theory and Learning Theory*.

We consider applications of computability theoretic techniques to algorithmic learning theory. In particular, we use such techniques to answer a long-standing open question on the relative strength of two models of learning and to provide insight into the nature and fundamental complexity of four standard models of learning: finite learning, learning in the limit, behaviourally-correct learning and anomalous learning. (Received March 03, 2013)

1090-03-255 **Iraj Kalantari*** (i-kalantari@wiu.edu), Mathematics Department, Western Illinois University, Macomb, IL 61455. *Computability in Topology and Analysis: On extendibility of functions and series of computable functions and their convergence to computable functions*.

In an earlier work with Larry Welch, we had shown that, given any $\varepsilon > 0$, there is a computable, and thus continuous, function f_ε on the unit interval whose domain has measure less than ε and which is nonextendible to a continuous function whose domain properly includes f_ε 's domain. Using new machinery, we now report on existence of a computable, and thus continuous, function f on the unit interval whose domain is of Lebesgue measure zero and which is also nonextendible to a continuous function whose domain properly includes f 's domain.

We accomplish this in our point-free approach to computable topology and analysis. In that approach we name points via nested sequences of basic open sets, and thus our functions on a topological space are generated by functions from basic open sets to basic open sets. We pursue the construction of a function that produces the sum of a series of computable partial functions with *varying domains*. We introduce a general technique for reconciling the varying domains of the series to produce a computable function, and apply the technique to produce f mentioned above. (Received March 03, 2013)

1090-03-271 **Uri Andrews, Mingzhong Cai*** (mcai@math.wisc.edu), **David Diamondstone, Steffen Lempp** and **Joseph S. Miller**. *Degrees of Provability*. Preliminary report.

Given two recursive functions f and g (with fixed algorithms), we say f is provably reducible to g if the totality of g proves the totality of f over some fixed base theory (for example, Peano Arithmetic). We study the induced degree structure on the recursive functions, i.e., all total recursive functions modulo provable equivalence. This is essentially the Lindenbaum algebra restricted on true Π_2^0 sentences. We use ideas and methods from classical recursion theory to study this proof-theoretic degree structure. In addition to the induced order relation, there are two natural jump-like operators in the degrees. Sample theorems include density theorem, diamond theorem, jump inversion theorem and high/low hierarchy. (Received March 03, 2013)

1090-03-275 **Valentina Harizanov*** (harizanov@gwu.edu), Department of Mathematics, George Washington University, Washington, DC 20052. *Complexity of orders on residually nilpotent groups*.

A bi-order on a group is a linear order of the elements of its domain, which is both left-invariant and right-invariant with respect to the group operation. That is, a bi-order is both a left order and a right order. We investigate the complexity of orders on orderable, finitely presented, residually nilpotent groups. This class of groups includes important surface groups. We show that a computable, torsion-free, finitely presented, residually nilpotent but not nilpotent group has a bi-order in every truth-table degree. This is joint work with J. Chubb and M. Dabkowski. (Received March 03, 2013)

1090-03-300 **Brian Rice*** (brice@math.wisc.edu), University of Wisconsin - Madison, Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706. *The Thin Set Theorem for Pairs implies DNR*. Preliminary report.

Of the Ramsey-like combinatorial principles which have been studied in reverse mathematics, the Thin Set Theorem is among the weakest. The Thin Set Theorem for pairs, TS(2), states that for any coloring function $f : [\omega]^2 \rightarrow \omega$ of unordered pairs of integers with (up to) countably many colors, there is an infinite *thin set* such that f restricted to pairs from A omits at least one color; that is, an infinite set A such that $f([A]^2) \subsetneq \omega$. This principle is a greatly weakened form of Ramsey's theorem for pairs, and though it is not implied by the base theory RCA_0 , it has acquired something of a reputation for being uselessly weak. Until recently, TS(2) was not known to imply any "interesting" principles of reverse mathematics. Inspired by a proof that the principle DNR (that for any set A there exists a set diagonally non-computable relative to A) is implied by SRT_2^2 , we show that, in fact, TS(2) implies DNR over RCA_0 . (Received March 04, 2013)

1090-03-336 **Uri Andrews, Mingzhong Cai and David Diamondstone***, ddiamondstone@gmail.com, and **Steffen Lemp** and **Joseph Miller**. *Degree Spectra of Theories*. Preliminary report.

A classic problem in computable model theory is the problem of computing a copy of a given structure. The difficulty of this problem is measured by the degree spectrum of the structure: the set of Turing degrees which can present a structure isomorphic to the given structure. Andrews and Miller recently introduced an analogue for theories, which measures how hard it is to present a model of the given theory. We give several interesting, natural examples of degree spectra of theories. For example, we show that for all n ,

$$\{\mathbf{d} : \mathbf{d} \not\leq \mathbf{0}^{(n)}\}$$

is the degree spectrum of a theory. For $n \geq 2$, this collection of degrees is known, by a result of Andrews, Cai, Lemp, Miller, and Kalimullin, not to be the degree spectrum of a structure. (Received March 04, 2013)

1090-03-347 **François G. Dorais** (francois.g.dorais@dartmouth.edu), **Damir D. Dzhafarov** (damir@math.berkeley.edu), **Jeffrey L. Hirst** (jlh@math.appstate.edu), **Joseph R. Mileti*** (miletijo@grinnell.edu) and **Paul Shafer** (pshafer@liafa.univ-paris-diderot.fr). *Uniformly Computable Reductions Between Mathematical Theorems*.

The program of reverse mathematics provides a framework for determine when a theorem P reduces to another theorem Q . In this setting, one works in a formalized system over a weak base theory that is intended to capture "effective" or "computable" mathematics. Although this is a very celebrated framework with many successes, it requires some nontrivial background in syntactic logic and is in some ways too coarse.

We will discuss a new approach that says theorem P reduces to theorem Q if there exists a uniformly computable transformation from instances of P into instances of Q , and another backward uniformly computable transformation from solutions to an instance of Q to solutions of the corresponding instance of P . This approach sometimes leads to finer distinctions between mathematical theorems and perhaps a more mathematically natural notion of reduction due to its avoidance of formal systems. (Received March 04, 2013)

1090-03-393 **Andrew John Ylvisaker*** (andrewy@iastate.edu), 396 Carver Hall, Iowa State University, Ames, IA 50010. *The superfluity of equality*.

In 1985 István Németi first showed that 3-variable logic is sufficiently rich for the study of set theory. At the same time he asked whether a similar result could be obtained without requiring the equality relation. This was answered in the affirmative in 2011. We present a description of the essential difficulty in removing equality, along with the key lemma from the proof that it can be done. (Received March 05, 2013)

1090-03-423 **Richard L Kramer*** (ricardo@iastate.edu), 903 Furman Dr, Ames, IA 50010. *Some new weak representations of certain finite relation algebras*.

A relation algebra is an algebraic structure extending Boolean algebras modeling the algebra of binary relations on a set, with an additional unary operator and a binary operator to model relational converse and composition of relations, respectively, along with a constant to represent the identity relation, subject to certain equational axioms true for actual binary relations on a set.

A (square) representation of a relation algebra is a homomorphism from the relation algebra into the set of all binary relations on a set U , preserving the Boolean operations as well as converse, the relational product, and the identity element.

A (square) weak representation weakens the conditions on a (square) representation by not requiring that the operations of "+" (union) and "-" (complementation) be preserved.

We will present and discuss some new examples of (square) weak representations of finite relation algebras which are not representations. (Received March 05, 2013)

1090-03-432 **Iraj Kalantari** (i-kalantari@wiu.edu) and **Mojtaba Moniri*** (m-moniri@wiu.edu), Department of Mathematics, Western Illinois University, 1 University Circle, Macomb, IL 61455. *On computability and complexity of Pierce and Engel expansions*. Preliminary report.

We present algorithms generating the Pierce and Engel expansions of certain real numbers and compare their sub-recursive complexity to that of several other presentations, including continued fractions and the Beatty sequence approach. Among the numbers we consider, is Plouffe's constant $\arctan(1/2)/\pi$. (Received March 05, 2013)

05 ► Combinatorics

1090-05-19 **Jonathan E Beagley** (jbeagley@gmu.edu), Department of Mathematical Sciences, George Mason University, Fairfax, VA 22030, and **Walter D Morris*** (wmorris@gmu.edu), Department of Mathematical Sciences, George Mason University, Fairfax, VA 22030. *Chromatic Numbers of Copoint Graphs of Convex Geometries*.

We study the copoint graph of a convex geometry. We give a family of copoint graphs for which the ratio of the chromatic number to the clique number can be arbitrarily large. For any natural numbers $1 < d < k$, we study the existence of a number $K_d(k)$ so that the chromatic number of the copoint graph of a convex geometry on a set of at least $K_d(k)$ elements, with every d -element subset closed, has chromatic number at least k . Our results are analogues of results of Erdős and Szekeres for convex geometries realizable by point sets in \mathbb{R}^m , where cliques in the copoint graph correspond to subsets of points in convex position. (Received January 05, 2013)

1090-05-21 **Bangteng Xu*** (bangteng.xu@eku.edu), Department of Mathematics and Statistics, Eastern Kentucky University, Richmond, KY 40474, and **Kezheng Kuo**, Department of Mathematics and Statistics, Hubei Normal University, Huangshi, Hubei 435002, Peoples Rep of China. *On Semisimple Varietal Terwilliger Algebras Whose Non-primary Ideals Are 1-dimensional*.

A varietal Terwilliger algebra is an abstraction of the Terwilliger algebra of a commutative association scheme. There exists a varietal Terwilliger algebra defined by any given standard C -algebra, and a generalized Terwilliger algebra defined by Egge is also a varietal Terwilliger algebra. Characterizations of a semisimple varietal Terwilliger algebra with 1-dimensional non-primary ideals will be discussed, and applications to association schemes will be presented. (Received January 17, 2013)

1090-05-31 **Jaewoo Lee*** (jalee@bccc.cuny.edu), Department of Mathematics, Borough of Manhattan Community College, 199 Chambers Street, New York, NY 10007. *Geometry of numbers and sumsets*.

This talk will be motivated by the study of numbers and their geometry in general. In particular, we will talk about some of recent improvements on Minkowski's theorem on geometry of numbers. This naturally leads to questions of geometry of sumsets. When you start with a finite set of integral points in a given dimension, and take its iterated sumsets, its size is known to grow as a polynomial. We will talk about how they grow geometrically inside their convex hulls and how this might be useful when you count lattice points in polytopes. (Received January 18, 2013)

1090-05-33 **L. Thoma*** (thoma@math.uri.edu), Department of Mathematics, University of Rhode Island, Kingston, RI 02881. *2-colorability of hypergraphs using commutative algebra*.

A hypergraph is properly 2-colorable if each vertex can be colored by one of two colors such that no edge is monochromatic. In 1997 Hillar gave a complete characterization of the k -colorability of graphs using algebraic methods. We generalize Hillar's work and give a complete algebraic characterization of the 2-colorability of r -uniform hypergraphs. Further, we prove a decomposition result for hypergraph 2-colorings and use it to determine if a hypergraph is conflict-free colorable or not. Joint work with M. Krul. (Received January 22, 2013)

1090-05-40 **Gabor Heteyi*** (gheteyi@unc.c.edu), Department of Mathematics & Statistics, 9201 University City Blvd, Charlotte, NC 28223-0001, and **Sarah Birdsong** (sjbirds@unc.c.edu), Department of Mathematics & Statistics, 9201 University City Blvd, Charlotte, NC 28223-0001. *An adjacent transposition Gray code for essentially different shelling orders of the boundary of a hypercube.*

We identify two shellings of the boundary of the hypercube if one can be transformed into the other by an isometry of the cube. The equivalence classes thus obtained may be encoded by a class of indecomposable permutations, bijectively equivalent to standard double occurrence words. We construct an adjacent transposition Gray code for this class of permutations. This construction can be implemented in constant amortized time. Our result is a signed variant of King's result showing that there is a transposition Gray code for indecomposable permutations. (Received January 22, 2013)

1090-05-41 **Lindsay Anne Erickson*** (lerick15@cord.edu), lerick15@cord.edu, and **Joshua Lambert**. *Uniform hypergraphs and the game of Nim.* Preliminary report.

We expand the study of Nim on graphs by considering the game on the k -uniform hypergraphs. We first define the method of play, discuss similarities and differences with ordinary graphs, then look at some specific cases of game play. We present the complete solution for Nim on the unit weight Fano plane and known results in the arbitrary weight case of Nim on the Fano plane. Finally, we present some conjectures for more general arbitrary weight play on any k -uniform hypergraph. (Received January 24, 2013)

1090-05-44 **Daniel W. Cranston*** (dcranston@vcu.edu) and **Landon Rabern**. *Coloring claw-free graphs with $\Delta - 1$ colors.*

Borodin and Kostochka conjectured that every graph with maximum degree $\Delta \geq 9$ with no clique on Δ vertices has chromatic number at most $\Delta - 1$. We prove this conjecture for claw-free graphs, i.e., those with no induced $K_{1,3}$. This is joint work with Landon Rabern, of Arizona State University. (Received January 27, 2013)

1090-05-45 **V. Coll, C. Magnant** and **H. Wang*** (hwang@georgiasouthern.edu). *Winding up and down in meanders.* Preliminary report.

We consider meanders, a graph representation of seaweed algebras. By examining the meanders from a combinatorial point of view, some interesting observations are made regarding Frobenius meanders and the spectrum of a Frobenius meander. This is joint work with Vincent Coll and Colton Magnant. (Received January 27, 2013)

1090-05-53 **Andre RASPAUD*** (raspaud@labri.fr), LaBRI, Bordeaux University, 351, cours de la Liberation, 33450 TALENCE, France. *On (i, j, k) -coloring of sparse graphs.*

A graph G is (i, j, k) -colorable if the vertex set of G can be partitioned into three subsets V_1, V_2, V_3 such that the graph $G[V_1]$ (resp. $G[V_2], G[V_3]$) induced by the vertices of V_1 (resp. V_2, V_3) has maximum degree at most i (resp. j, k). In this talk we give conditions on the maximum average degree of a graph G that imply that G admits an (i, j, k) -coloring with $i + j + k = 3$. (Received February 06, 2013)

1090-05-55 **Richard P Anstee*** (anstee@math.ubc.ca), UBC Mathematics, Vancouver, BC V6T1Z2, Canada, and **Christina Koch**. *Forbidden Families of Configurations.* Preliminary report.

We consider the problem of forbidden configurations. Define a matrix to be *simple* if it is a $(0,1)$ -matrix with no repeated columns. We may think of this as the incidence matrix of a simple hypergraph. For a given $(0,1)$ -matrix F , we say a matrix A has no *configuration* F if there is no submatrix of A which is a row and column permutation of F . Given m and a family \mathcal{F} of forbidden configurations, we seek a bound $\text{forb}(m, \mathcal{F})$ on the number of columns in an m -rowed simple matrix which has no configuration in \mathcal{F} .

There is an attractive, unresolved conjecture of Anstee and Sali which predicts the asymptotics of the bound $\text{forb}(m, \mathcal{F})$ when $|\mathcal{F}| = 1$. We consider some interesting cases involving forbidding a (finite) family of forbidden configurations. Some cases have bounds predicted by the conjecture and some do not. This is joint work with Christina Koch, Miguel Raggi and Attila Sali. (Received February 06, 2013)

1090-05-63 **David Galvin*** (dgalvin1@nd.edu), Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556. *Counting colorings of a regular graph.*

In the 1980's, Wilf and Linial asked which order n , size m graph admits the most proper q -colourings for each q . Although there have been some partial results, the question is still wide open, and it seems that the answer depends quite sensitively on n , m and q .

Recently, the analogous question has been asked for the more restrictive class of order n , d -regular graphs. Here, there is a very appealing conjecture: when $2d$ divides n , the answer (for all q) is the disjoint union of $n/2d$ copies of $K_{d,d}$, the complete bipartite graph with d vertices in each partite set.

If we restrict to bipartite graphs, the conjecture is true. For regular graphs which are close to being bipartite, in the sense that they have an independent set consisting of roughly half the vertices, an approximate version of the conjecture is known.

Here we look at the other side of the picture. We put an upper bound on the number of q -colourings admitted by a regular graph in terms of the independence number of the graph, and so show that the conjecture is true for every regular graph that is not too close to being bipartite. (Received February 09, 2013)

1090-05-64 **O. V. Borodin** (brdnoleg@math.nsc.ru), Sobolev Institute of Mathematics, Novosibirsk, 630090, Russia, **A. Kostochka*** (kostochk@math.uiuc.edu), Department of Mathematics, 1409 W. Green St., Urbana, IL 61801, **B. Lidicky** (lidicky@illinois.edu), Department of Mathematics, 1409 W. Green St., Urbana, IL 61801, and **M. Yancey** (yancey1@illinois.edu), Department of Mathematics, 1409 W. Green St., Urbana, IL 61801. *Planar and sparse 4-critical graphs with four triangles*. Preliminary report.

A sharpening of Grötzsch Theorem, the Grünbaum-Axenov Theorem, states that every planar graph with at most three triangles is 3-colorable. It turns out that the family \mathcal{P}_4 of 4-critical plane graphs with exactly four triangles is infinite. Moreover, Thomas and Walls showed that even the family \mathcal{P}'_4 of graphs in \mathcal{P}_4 with no 4-faces is infinite by constructing an infinite series of graphs in \mathcal{P}'_4 . An interesting question probably asked first by Axenov in seventies is to describe graphs in \mathcal{P}_4 .

We describe graphs in \mathcal{P}'_4 in two steps. First, we consider the family \mathcal{F} of 4-critical graphs G with $5|V(G)| = 3|E(G)| + 2$. We prove that each graph in \mathcal{F} has at least four triangles and that the subfamily \mathcal{F}_4 of the graphs in \mathcal{F} having exactly four triangles equals \mathcal{P}'_4 . Then we describe all graphs in \mathcal{F}_4 . It turns out that they are essentially Thomas-Walls graphs with small deviations. (Received February 11, 2013)

1090-05-82 **Ilkyoo Choi***, ichoi4@illinois.edu, and **Henry A Kierstead, Landon Rabern and Bruce Reed**. *The list version of Borodin-Kostochka Conjecture for graphs with large maximum degree*.

Brooks' Theorem states that for a graph G with maximum degree $\Delta(G)$ at least 3, the chromatic number is at most $\Delta(G)$ when the clique number is at most $\Delta(G)$. Vizing proved that the list chromatic number is also at most $\Delta(G)$ under the same conditions. Borodin and Kostochka conjectured that a graph G with maximum degree at least 9 must be $(\Delta(G) - 1)$ -colorable when the clique number is at most $\Delta(G) - 1$; this was proven for graphs with maximum degree at least 10^{14} by Reed. In this paper, we prove an analogous result for the list chromatic number; namely, we prove that a graph G with $\Delta(G) \geq 10^{20}$ is $(\Delta(G) - 1)$ -choosable when the clique number is at most $\Delta(G) - 1$. This is joint work with H. A. Kierstead, L. Rabern, and B. Reed. (Received February 18, 2013)

1090-05-102 **Katherine Benson*** (katherine-f-benson@uiowa.edu). *Lower Bound Techniques for Radio Numbers of Trees*. Preliminary report.

A radio labeling of a simple connected graph G with diameter D is a function $f : V(G) \rightarrow \mathbb{Z}^+$ such that for every two distinct vertices u and v of G , the radio condition, $d(u, v) + |f(u) - f(v)| \geq D + 1$ is satisfied. The radio number of a graph G is the smallest integer m for which there exists a radio labeling f with $f(v) \leq m$ for all $v \in V(G)$. In this talk, we will discuss strategies that can be used to determine a reasonable lower bound for the radio number of certain tree graphs. (Received February 21, 2013)

1090-05-103 **Nicholas A. Loehr*** (nloehr@vt.edu) and **R. Daniel Mauldin**. *Bijective proofs of Jensen's identity and Mohanty-Handa's identity*.

Jensen's identity states that $\sum_{m=0}^n \binom{x+mz}{m} \binom{y-mz}{n-m} = \sum_{k=0}^n \binom{x+y-k}{n-k} z^k$. This identity arises in probability in the study of Dirichlet distributions and Pólya urn schemes. We give two bijective proofs of Jensen's identity based on lattice path combinatorics. Our technique extends to prove a multivariate generalization called Mohanty-Handa's identity. (Received February 21, 2013)

1090-05-104 **Leonid Gurvits*** (l.n.gurvits@gmail.com), North Academic Center, 8/206, 160 Convent Avenue, New York, NY 10031. *The Bethe approximation, correlation inequalities and lower bounds on the permanent: how Friedland's monomer-dimer conjecture(LAMC) was proved and Lu-Mohr-Szekely was disproved*. Preliminary report.

The Bethe Approximation(BA) is a popular, non-rigorous heuristic in stat. physics and machine learning. I will describe a completely kosher application of (BA) to the approximation of the permanent. In particular, a proof of Friedland's monomer-dimer conjecture will be sketched. Time permitting, some new probabilistic interpretations of lower bounds on the permanent and related new conjectures will be covered. (Received February 21, 2013)

1090-05-111 **James M Carraher*** (s-jcarrah1@math.unl.edu), **Stephen G Hartke** and **Paul Horn**. *Edge-disjoint rainbow spanning trees in complete graphs.*

Let G be a properly edge-colored copy of the complete graph K_n . A rainbow spanning tree is a spanning tree of G where each edge has a different color. Brualdi and Hollingsworth and Kaneko, Kano, and Suzuki conjecture that every complete graph K_n ($n \geq 6$) has $\lfloor n/2 \rfloor$ edge-disjoint rainbow spanning trees. We show that G ($n \geq 1000$) contains at least $\lfloor n/(300 \log n) \rfloor$ edge-disjoint rainbow spanning trees. (Received February 22, 2013)

1090-05-114 **Anton Betten*** (betten@math.colostate.edu), Colorado State University, Department of Mathematics, Fort Collins, CO 80523-1874. *Spreads and Packings in $PG(3, q)$.*

In projective three-space, a spread is a collection of lines such that each point is on one and only one of the lines of the spread. A packing is a set of spreads such that each line is in one and only one line of the packing. We consider the projective space $PG(3, q)$ defined over the finite field with q elements. In this case, a spread has $q^2 + 1$ lines and a packing consists of $q^2 + q + 1$ spreads. In general, there are many ways that spreads and packings can be formed, and we are interested in determining these ways up to the action of the automorphism group of the space. This is the classification problem for spreads and packings. To solve this problem, we rely on the method of *breaking the symmetry*. This is using the theory of permutation groups to classify orbits step-by-step. We present new results regarding spreads in $PG(3, q)$ for $q = 8$ and $q = 9$, under the additional hypothesis that they contain a regulus. We also classify the packings of $PG(3, 3)$. (Received February 23, 2013)

1090-05-121 **Linyuan Lu** and **Xing Peng***, Department of Mathematics, University of California, San Diego, La Jolla, CA 92093. *High order phase transition in random hypergraphs.*

Given an r -uniform hypergraph, we define the s -th-order connected component and the giant s -th-order connected component for each $1 \leq s \leq r - 1$. Let $H^r(n, p)$ be the random r -uniform hypergraph with the vertex set $[n]$, where each r -set of $[n]$ is included as an edge independently with probability p . We determine the threshold for the existence of the giant s -th-order connected component for each $1 \leq s \leq r - 1$; we also manage to give the size of the largest s -th-order connected component in the supercritical phase and the subcritical phase. For the case $s = 1$, there are some results on the uniform model $H_{n,m}^r$ due to Schmidt-Pruzan and Shamir; Karoński and Łuczak. Our result agrees with previous known results for the case $s = 1$. This is joint work with Linyuan Lu. (Received February 24, 2013)

1090-05-125 **Gwenaël Joret**, **Piotr Micek**, **Kevin G Milans** and **William T Trotter*** (trotter@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, 686 Cherry Street, Atlanta, GA 30332, and **Bartosz Walczak** and **Ruidong Wang**. *Tree-width and Dimension.*

Over the last 30 years, researchers have investigated connections between dimension for posets and planarity for graphs. Here we extend this line of research to the structural graph theory parameter tree-width by proving that the dimension of a finite poset is bounded in terms of its height and the tree-width of its cover graph. (Received February 25, 2013)

1090-05-129 **Jie Han** and **Yi Zhao*** (yzhao6@gsu.edu). *Minimum vertex degree threshold for loose Hamilton cycles in 3-graphs.*

A loose Hamilton cycle in 3-uniform hypergraphs (3-graphs) is a spanning cycle in which two consecutive edges share a single vertex. Recently Buss, Hàn and Schacht proved that every 3-graph H on n vertices with the minimum vertex degree at least $(7/16 + o(1))\binom{n}{2}$ contains a loose Hamilton cycle. We improve this result by giving the exact minimum degree threshold. (Received February 25, 2013)

1090-05-152 **Hein van der Holst*** (hvanderholst@gsu.edu), **Marina Arav**, **Frank Hall** and **Zhongshan Li**. *Colin de Verdière-type invariants for signed graphs and odd- K_4 - and odd- K_3^2 -free signed graphs.*

A signed graph is a pair (G, Σ) where G is an undirected graph (we allow parallel edges but no loops) and $\Sigma \subseteq E(G)$. The edges in Σ are called odd and the other edges are called even. If (G, Σ) is a signed graph with n vertices, $S(G, \Sigma)$ is the set of all symmetric $n \times n$ matrices $A = [a_{i,j}]$ with $a_{i,j} > 0$ if i and j are adjacent and connected by only odd edges, $a_{i,j} < 0$ if i and j are adjacent and connected by only even edges, $a_{i,j} \in \mathbb{R}$ if i and j are connected by both even and odd edges, $a_{i,j} = 0$ if i and j are not connected by any edges, and $a_{i,i} \in \mathbb{R}$ for all vertices i .

For a signed graph (G, Σ) , $\nu(G, \Sigma)$ is defined as the maximum of the nullities of positive definite matrices $A \in S(G, \Sigma)$ that have the Strong Arnold Hypothesis. This invariant is closed under taking minors, and characterizes signed graphs with no odd- K_4 - and no odd- K_3^2 -minor as those signed graphs (G, Σ) with $\nu(G, \Sigma) \leq 2$. In this talk we will discuss $\nu(G, \Sigma)$ and characterizations. (Received February 27, 2013)

1090-05-157 **Jaehoon Kim***, Department of Mathematics, 1409 W. Green Street, Urbana, IL IL61801, and **Alexandr V Kostochka** and **Xuding Zhu**. *(0,1)-improper coloring of sparse graph.*

A graph G is a $(0,1)$ -colorable if $V(G)$ can be partitioned into two sets V_0 and V_1 so that $G[V_0]$ is an independent set and $G[V_1]$ has maximum degree at most 1. The problem of verifying whether a graph is $(0,1)$ -colorable is NP-complete even in the class of planar graphs of girth 9.

Maximum average degree, $Mad(G) = \max_{H \subset G} \left\{ \frac{2|E(H)|}{|V(H)|} \right\}$, is a graph parameter measuring how sparse the graph G is. Borodin and Kostochka showed that every graph G with $Mad(G) \leq \frac{12}{5}$ is $(0,1)$ -colorable, thus every planar graph with girth at least 12 also is $(0,1)$ -colorable.

The aim of this talk is to prove that every triangle-free graph G with $Mad(G) \leq \frac{22}{9}$ is $(0,1)$ -colorable. We prove the slightly stronger statement that every triangle-free graph G with $|E(H)| < \frac{11|V(H)|+5}{9}$ for every subgraph H is $(0,1)$ -colorable and show that there are infinitely many not $(0,1)$ -colorable graphs G with $|E(G)| = \frac{11|V(G)|+5}{9}$. (Received February 27, 2013)

1090-05-161 **Csaba Biró*** (csaba.biro@louisville.edu) and **Udayan B Darji** (ubdarj01@louisville.edu). *Generating infinite random graphs.*

Consider the following process: given a sequence of nonnegative integers $\{d_n\}_{n=0}^{\infty}$ with the property that $d_i \leq i$ (in particular $d_0 = 0$), construct a random graph on countably infinitely many vertices v_0, v_1, \dots , with the following process: each new vertex i is connected to a d_i -subset of the vertices $\{v_0, \dots, v_{i-1}\}$, where the subset is chosen uniformly at random. We study the resulting probability space. (Received February 27, 2013)

1090-05-162 **Luz M. DeAlba*** (luz.dealba@drake.edu). *Matchings and Minimum Skew Zero Forcing Sets of Some Multipartite Graphs.* Preliminary report.

The minimum skew rank of a simple graph G over a field \mathbb{F} is the smallest possible rank among all skew-symmetric matrices, over \mathbb{F} , whose (i, j) -entry (for $i \neq j$) is nonzero whenever $\{i, j\}$ is an edge in G and is zero otherwise.

Let G be a graph, and Z a subset of its vertices, which we color black, while the remaining are colored white. We define the skew color change rule as follows: if u is a vertex of G , and exactly one of its neighbors v , is white, then change the color of v to black. The set Z is a skew zero forcing set for G if the application of the skew color change rule (as many times as necessary) will result in all the vertices in G colored black. Z is a minimum skew zero forcing set of G if it is a set of least cardinality among all skew zero forcing sets of G .

In the presentation we discuss relations between minimum skew zero forcing sets and matchings in some multipartite graphs. (Received February 27, 2013)

1090-05-170 **Joshua N. Cooper** (cooper@math.sc.edu), Department of Mathematics, University of South Carolina, 1523 Greene St., Columbia, SC 29208, and **Aaron M. Dutle*** (dutle@math.sc.edu), Interdisciplinary Mathematics Institute, University of South Carolina, 1523 Greene St., Columbia, SC 29208. *Counting Sub-Hypergraphs and the Characteristic Polynomial.*

The adjacency hypermatrix of a k -uniform hypergraph on n vertices is an order k , dimension n array, where an entry of the array is 1 if the indices correspond to an edge, and 0 otherwise. Using recent developments in the spectral theory of hypermatrices, the authors previously defined and investigated the eigenvalues and characteristic polynomial of k -uniform hypergraphs. In this talk, we show an analogue to a classical theorem in the spectral theory of graphs, which says that the coefficients of the characteristic polynomial depend only on the number of times certain subgraphs appear. (Received February 28, 2013)

1090-05-176 **Gonzalo Fiz Pontiveros, Simon Griffiths, Rob Morris, David Saxton and Jozef Skokan*** (jozef@member.ams.org). *On the Ramsey number of the triangle and the cube.*

The Ramsey number $r(K_3, Q_n)$ is the smallest integer N such that every red-blue colouring of the edges of the complete graph K_N contains either a red n -dimensional hypercube, or a blue triangle. Almost thirty years ago, Burr and Erdős conjectured that $r(K_3, Q_n) = 2^{n+1} - 1$ for every positive integer n , but the first non-trivial upper bound was obtained only recently, by Conlon, Fox, Lee and Sudakov, who proved that $r(K_3, Q_n) \leq 7000 \cdot 2^n$. Here we show that $r(K_3, Q_n) = (1 + o(1))2^{n+1}$ as $n \rightarrow \infty$. (Received February 28, 2013)

1090-05-187 **Jonathan Cutler** and **A J Radcliffe*** (aradcliffe1@math.unl.edu). *Graphs of given maximum degree with the most cliques.*

There has been a variety of recent work on extremal problems for the enumeration of special subsets of graphs, such as independent sets, perfect matchings, etc. I will discuss recent work concerning the problem of finding the maximum number of cliques in a graph of given maximum degree. This is complementary to work by Galvin

and Engbers on the number of independent sets in a graph with given minimum degree. (Received February 28, 2013)

1090-05-190 **Jennifer Iglesias, Nathaniel Ince and Po-Shen Loh*** (ploh@cmu.edu), Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213. *Computing with voting trees.*

The classical paradox of social choice theory asserts that there is no fair way to deterministically select a winner in an election among more than two candidates. One well-studied procedure for selecting a winner is to specify a complete binary tree whose leaves are labeled by the candidates, and evaluate it by running pairwise elections between the pairs of leaves, sending the winners to successive rounds of pairwise elections which ultimately terminate with a single winner. This structure is called a voting tree.

Much research has investigated which functions on tournaments are computable in this way. Fischer, Procaccia, and Samorodnitsky quantitatively studied the computability of the Copeland rule, which returns a vertex of maximum out-degree in the given tournament. The best previously known voting tree could only guarantee a returned out-degree at least $\lfloor \log_2 n \rfloor$. Our work finds three constructions, the first of which substantially improves this guarantee to $\Theta(\sqrt{n})$. The other two demonstrate the richness of the voting tree universe, with a tree that resists manipulation, and a tree which implements arithmetic modulo three. (Received February 28, 2013)

1090-05-199 **Junbo Huang*** (j26huang@uwaterloo.ca). *Sets of Complex Unit Vectors and Distance-Regular Graphs.* Preliminary report.

A set of unit vectors in \mathbb{C}^m with the property that the standard inner product of distinct vectors in the set has absolute value 0 or α (with $\alpha \neq 0$) is called a $\{0, \alpha\}$ -set. A vector in \mathbb{C}^m is called *flat* if all of its entries have the same absolute value. In 2005, Godsil and Roy found a construction of $\{0, \alpha\}$ -sets of flat vectors using certain bipartite graphs. In this talk, I will sketch the construction by Godsil and Roy. I will then present bounds on the sizes of $\{0, \alpha\}$ -sets of flat vectors in \mathbb{R}^m and \mathbb{C}^m , and I will talk about the distance-regular graphs that can be used to produce $\{0, \alpha\}$ -sets that meet these bounds at equality. (Received March 01, 2013)

1090-05-217 **Penny Haxell*** (pehaxell@uwaterloo.ca). *Extremal hypergraphs for packing and covering.*

A *packing* (or *matching*) in a hypergraph H is a set of pairwise disjoint edges of H . A *cover* of H is a set C of vertices that meets all edges of H . A famous open problem known as Ryser's Conjecture states that any r -partite r -uniform hypergraph should have a cover of size at most $(r-1)\nu(H)$, where $\nu(H)$ denotes the size of a largest packing in H . This was proved by Aharoni in 2001 for the case $r=3$. Here we show that if equality holds in this case then H belongs to a special class of hypergraphs we call "home base hypergraphs". To prove this we need to establish some auxiliary results on connectedness of the matching complex of bipartite graphs. (Joint work with L. Narins and T. Szabó) (Received March 01, 2013)

1090-05-218 **Seth A Meyer*** (seth.meyer@snc.edu), 100 Grant St., Saint Norbert College, Mathematics Discipline, De Pere, WI 54115. *Minimum rank for circulant graphs and bipartite circulant graphs.* Preliminary report.

There are many known bounds on the minimum rank of a graph, the two we will focus on are the minimum semi-definite rank and the zero forcing number. While much is known about these parameters for small graphs, families of large graphs remain an object of study. In this talk we will discuss bounds on the minimum rank of graphs with circulant adjacency matrices, more commonly known as circulant graphs. (Received March 01, 2013)

1090-05-228 **Jonathan D.H. Smith*** (jdsmith@iastate.edu), Department of Mathematics, 396 Carver Hall, Iowa State University, Ames, IA 50011. *Association schemes and fast matrix multiplication.* Preliminary report.

The direct definition of the product of two $n \times n$ matrices involves n^3 multiplications. In the late 1960s, Strassen showed that fewer multiplications actually suffice. Let ω be the minimal exponent such that $n^{\omega+o(1)}$ multiplications are needed for large n . Then $2 \leq \omega < 3$, and Strassen's algorithm shows that $\omega \leq \log_{2^3}(7^3) < 2.81$.

The purpose of this talk is to give a brief, simplified survey of some ideas, due most notably to Cohn and Umans, that aim to use association scheme and coherent configuration constructions in order to decrease the known upper bounds on ω , and tackle the conjecture stating that $\omega = 2$. (Received March 02, 2013)

1090-05-229 **Jeremy F Alm*** (alm.academic@gmail.com), 1101 W. College Ave., 821 W. Douglas, Jacksonville, IL 62650. *An infinite cardinal version of Gallai's Theorem for colorings of \mathbb{R}^n .* Two central results in Euclidean Ramsey Theory, both of which go by the name "Gallai's Theorem", are as follows:

Gallai's Theorem on \mathbb{Z}^n : Let S be a finite subset of \mathbb{Z}^n . Then any finite coloring of \mathbb{Z}^n contains a monochromatic subset homothetic to S .

Gallai's Theorem on \mathbb{R}^n : Let S be any finite subset of \mathbb{R}^n . Then any finite coloring of \mathbb{R}^n contains a monochromatic subset homothetic to S .

In this talk we discuss the following strengthening of Gallai's result:

Let $n, k \in \mathbb{Z}^+$, with $n > k$. Let \mathcal{S} be an n -element subset of \mathbb{R}^k , whose points are not all contained in any $(k-1)$ -dimensional hyperplane. If the points of \mathbb{R}^k are colored in finitely many colors, then there exist 2^{\aleph_0} monochromatic subsets homothetic to \mathcal{S} .

We will briefly sketch the proof, which uses Gallai's Theorem on \mathbb{Z}^n along with a partition of Euclidean Space. (Received March 02, 2013)

1090-05-231 **Oktay Olmez*** (oolmez@iastate.edu), Iowa State University, Ames, IA 50011. *$1\frac{1}{2}$ -designs and $1\frac{1}{2}$ -difference sets.*

Let $T = (\mathcal{P}, \mathcal{B}, \mathcal{I})$ be a tactical configuration with parameters (v, b, k, r) . For every point $x \in \mathcal{P}$ and every block $B \in \mathcal{B}$, let $\phi(x, B)$ be the number of flags $(y, C) \in \mathcal{I}$ such that $y \in B \setminus \{x\}$, $x \in C$ and $C \neq B$. A $1\frac{1}{2}$ -design with parameters $(v, b, k, r; \alpha, \beta)$ is a tactical configuration T such that

$$\phi(x, B) = \begin{cases} \alpha, & x \notin B; \\ \beta, & x \in B. \end{cases}$$

Examples of $1\frac{1}{2}$ -designs include 2-designs, transversal designs, and partial geometries. Let G be a (multiplicative) group and S be a non empty subset of G . For any $g \in G$, we define the *translate* of S by $gS = \{gs : s \in S\}$, and define the *development* of S by $\text{Dev}(S) = \{gS : g \in G\}$. S is called a $1\frac{1}{2}$ -difference set, if $(G, \text{Dev}(S))$ is a $1\frac{1}{2}$ -design. In this talk, we investigate the properties of $1\frac{1}{2}$ -difference sets via the group ring $\mathbb{Z}G$ and group characters. (Received March 02, 2013)

1090-05-247 **Ramin Javadi, Zeinab Maleki*** (zmaleki@illinois.edu) and **Behnaz Omoomi**. *Local Clique Covering of Graphs.*

A k -clique covering of a simple graph G , is an edge covering of G by its cliques such that each vertex is contained in at most k cliques. The smallest k for which G admits a k -clique covering is called *local clique cover number* of G and is denoted by $\text{lcc}(G)$. This parameter appears to have a lot of interesting relations and connections to other parameters on the graph and the concept can be interpreted as several other well-known problems. For instance, $\text{lcc}(G)$ is equal to the minimum number k for which G is isomorphic to the line graph of a k -uniform hypergraph. It is also related to a parameter called *Kneser index* of G , that is the minimum number k for which G is isomorphic to an induced subgraph of a Kneser graph $\text{kn}(n, k)$. Moreover, it has an interpretation as some kind of set representation for G . We investigate on several aspects of the problem and we obtain some upper and lower bounds in terms of other parameters of G . Then we focus on the case of *claw-free graphs* and we arise the question that how large the lcc of a claw-free graph can be. We answer this question completely, as well as the same question for a special family of claw-free graphs called linear interval graphs. (Received March 04, 2013)

1090-05-279 **Nathaniel Dean*** (nd17@txstate.edu), Department of Mathematics, 601 University Drive, San Marcos, TX 78666. *Zero Forcing Leads to Iteration and Domination.*

The zero forcing number of G is the minimum of $|Z|$ over all zero forcing sets $Z \subseteq V(G)$. We define the iteration index of G to be the the minimum number of iterations that must be applied to a minimum zero forcing set to select all vertices of G . In [Chilakamarri, Dean, Kang, Yi (2012)] some basic properties of the iteration index are presented along with some preliminary results for certain graph families.

The problem of monitoring an electrical power network can be modeled in terms of power dominating sets in a graph G , where a selected subset S of vertices in G is called a power dominating set if all vertices of G become selected by first selecting the neighbors of S and then using finitely many applications of the color-change rule. The power domination number of G is the minimum cardinality of a power dominating set of G . In [Dean, Ilic, Ramirez, Shen, Tian (2011)] the power domination number is determined for hypercubes Q_n with $n = 2^k$, where k is any positive integer. This is accomplished by first finding a connection between power dominating sets and zero forcing sets in a graph. Finally, we present a conjecture on the power domination number of hypercubes. (Received March 04, 2013)

1090-05-281 **Jozsef Solymosi*** (solymosi@math.ubc.ca), 1984 Mathematics Road, Vancouver, BC V6T1Z2, Canada. *On Erdős' unit distances problem*. Preliminary report.

In 1946 Erdős asked what is the maximum number of unit distances determined by a set of n points in the plane. He conjectured that the maximum is $o(n^{1+\varepsilon})$. The best upper bound is 30 years old, it is due to Spencer, Szemerédi, and Trotter who proved that the number of unit distances is $O(n^{4/3})$. In this talk we briefly review some results related to the problem. We illustrate why the $n^{4/3}$ bound is so hard to break and we mention some special cases when it is possible to show a $o(n^{1+\varepsilon})$ type bound. (Received March 04, 2013)

1090-05-284 **Michelle A Lastrina*** (lastrinm@dickinson.edu), Dickinson College, Department of Mathematics & Computer Science, PO Box 1773, Carlisle, PA 17013, and **Michael Young**. *Sum list coloring, the sum choice number, and sc-greedy graphs*.

Abstract: Let $G = (V, E)$ be a graph and f be a function assigning list sizes to the vertices of G . The graph G is f -choosable if every assignment of lists of colors to the vertices of G , where the list sizes agree with f , has a proper list-coloring of G . The sum choice number is the minimum of the sum of list sizes for f over all choosable functions f for G . The sum choice number of G is at most $|V| + |E|$. When the sum choice number of G is equal to this upper bound, G is said to be sc-greedy. In this talk, we will discuss ways to determine whether or not a graph is sc-greedy and how to compute the sum choice number of a graph. In particular, we will look at graphs on a small number of vertices and certain graphs made up of cycles. (Received March 04, 2013)

1090-05-285 **Catherine Erbes**, University of Colorado Denver, **Michael Ferrara*** (michael.ferrara@ucdenver.edu), University of Colorado Denver, **Ryan Martin**, Iowa State University, and **Paul Wenger**, Rochester Institute of Technology. *On the approximate shape of graphic sequences that are not potentially H -graphic*.

A sequence of nonnegative integers π is *graphic* if it is the degree sequence of some graph G . A graphic sequence π is *potentially H -graphic* if there is a realization of π that contains H as a subgraph.

Given nonincreasing graphic sequences $\pi_1 = (d_1, \dots, d_n)$ and $\pi_2 = (s_1, \dots, s_n)$, we say that π_1 *majorizes* π_2 if $d_i \geq s_i$ for all i , $1 \leq i \leq n$. In 2005, Pikhurko and Taraz showed that for any graph F with chromatic number $r + 1$, the degree sequence of an F -free graph is close to being majorized by the degree sequence of an r -partite graph. This extended a 1970 result of Erdős on the degree sequences of K_{r+1} -free graphs.

In this paper, we give similar results for degree sequences that are not potentially H -graphic. In particular, there is a graphic sequence $\pi^*(H)$ such that if π is a graphic sequence that is not potentially H -graphic, then π is close to being majorized by $\pi^*(H)$. (Received March 04, 2013)

1090-05-293 **Daniel Apon** and **William Gasarch***, gasarch@cs.umd.edu, and **Kevin Lawler**. *The complexity of Grid Coloring*.

A c -coloring of $[n] \times [m]$ is a mapping of $[n] \times [m]$ to $[c]$ such that no four corners forming a rectangle have the same color. In 2009 a challenge was proposed via the internet to find a 4-coloring of $[17] \times [17]$. This attracted much attention; however, it proved to be difficult. (It was solved.) Is the problem of grid coloring is difficult in general? YES: (1) Given a partial c -coloring of an $[n] \times [m]$ grid, can it be extended to a full c -coloring? is NP-complete. (2) If $[n] \times [m]$ is not c -colorable then the statement $[n] \times [m]$ is c -colorable, as a Boolean formula with nmc variables, requires $2^{\Omega(c)}$ to refute using tree-resolution. (3) We have exp lower bounds for tree cutting plane proofs. Note that items (2) and (3) yield statements from Ramsey Theory which are of size polynomial in their parameters and require exponential size in various proof systems. (Received March 04, 2013)

1090-05-308 **Benjamin C Cooper*** (cooper@math.colostate.edu). *Nonexistence of certain abstract hyperovals of order 12*.

Abstract hyperovals were introduced by Buekenhout in 1966, as a generalization of hyperovals in finite projective planes. The major open problem in the area is to show that they must have order a power of 2. Here we show the nonexistence of an abstract hyperoval of order 12 admitting a group of order 11 or 13. This latter result is a generalization of a 1997 result of Prince, who showed the nonexistence of an abstract hyperoval of order 12 admitting a Frobenius group of order 39. Our result is equivalent to showing the nonexistence of a partial geometry with parameters $(6,10,5)$ with a group of order 11 or 13. The nonexistence of an abstract hyperoval of order 10 was shown in 1983 by Lam, Thiel, Swiercz and McKay in as part of the proof of the nonexistence of a projective plane of order 10, so order 12 is the smallest open case. This is joint work with Tim Penttila. (Received March 04, 2013)

1090-05-320 **Kenneth W Johnson*** (kwj1@psu.edu). *Group schemes and fissions*. Preliminary report. If a finite group G acts on itself by left and right multiplication a well known scheme is produced. Equivalently one can take a set of variables $\{x_g\}_{g \in G}$, form the group matrix $X_G = \{x_{gh^{-1}}\}$ and identify $x_g = x_h$ if g is

conjugate to h . In probability theory X_G appears as the transition matrix X_G^p of a Markov chain which comes from a random walk on the group with probability distribution p , after x_g is replaced by $p(g)$. By the standard theory, if p is constant on conjugacy classes X_G^p can be diagonalised, and this simplifies the analysis.

The question which will be addressed is the following. Let R be an equivalence relation on G , and set $x_g = x_h$ iff gRh , giving rise to the matrix X_G^R . Under what conditions is X_G^R diagonalisable and in this case what is an upper bound for the number of classes of R ? If R is finer than conjugacy, this is equivalent to the corresponding fission of the association scheme being commutative. In the probability context, the answer gives a weaker condition for p such that X_G^p can be diagonalised. There are obvious generalisations. (Received March 04, 2013)

1090-05-322 **Stefaan De Winter*** (sgdewint@mtu.edu), 1400 Townsend Drive, Houghton, MI 49931.
Large incidence-free sets in geometries.

In this talk I want to focus on the following problem: let Γ be a C_4 -free bipartite graph with parts P and L , what is the largest value of $|X||Y|$, where $X \subset P$, $Y \subset L$ and such that there are no adjacencies between the vertices in X and those in Y ? I will mostly focus on the case where Γ is the incidence graph of an interesting geometry (projective plane, generalized polygon,...) However, at the end of the talk I will also discuss the case of a general partial linear space for which $|P| = |L|$. This is based on joint work with J. Schillewaert and J. Verstraete. (Received March 04, 2013)

1090-05-329 **M. Klin and A Woldar*** (andrew.woldar@villanova.edu), Department of Mathematics and Statistics, Villanova University, Villanova, PA 19085, and **M Ziv-Av**. *Triangle-free Strongly Regular Graphs: From Dale Mesner to a Modern Understanding*. Preliminary report.

In our talk, we discuss the state of knowledge on triangle free strongly regular graphs dating back to the early work of Dale Mesner in his 1956 Ph.D. thesis. We discuss some of the main properties of such graphs, elaborate certain constructions (some of which are new), and interject a bit history along the way. (Received March 04, 2013)

1090-05-335 **Michael Young*** (myoung@iastate.edu). *Maximum Nullity and Zero Forcing Number of Subdivided Graphs*.

For a simple, undirected graph G the zero forcing number, $Z(G)$, is the minimum number of blue vertices initially needed to force all vertices in G blue according to the color change rule. The color change rule states that in a graph where each vertex is colored blue or white, a vertex v can force an adjacent vertex w to be colored blue if v is blue and w is the only white neighbor of v .

The maximum nullity, $M(G)$, of G is the largest possible nullity over all real symmetric matrices whose ij th entry (for $i \neq j$) is nonzero whenever $\{i, j\}$ is an edge in G and is zero otherwise. The minimum rank, $mr(G)$, of G is $|G| - M(G)$. It is known that $M(G) \leq Z(G)$ for all G .

The complete subdivision graph, \dot{G} is obtained from G by subdividing each edge once. This talk will cover results relevant to $Z(\dot{G})$ and $M(\dot{G})$ and to the open question of whether these two quantities are equal. (Received March 04, 2013)

1090-05-338 **Bela Csaba*** (bcsaba@math.u-szeged.hu). *Well-separable graphs with large bandwidth*. Preliminary report.

Call a graph $H = (V, E)$ c -separable if there exists $S \subset V$ with $|S| \leq c|V|$ such that every component of $H - S$ has $o(|V|)$ vertices. We show that there exists a $c_0 > 0$ such that for all $0 < c \leq c_0$ there is a class of graphs \mathcal{H}_c containing bipartite c -separable graphs with bounded degree so that the following holds. There exists a threshold n_0 such that

- (1) every $H \in \mathcal{H}_c$ on $n \geq n_0$ vertices has bandwidth $> |V(H)|/20$;
- (2) assume that $n \geq n_0$. If $H \in \mathcal{H}_c$ has n vertices, G is a graph on n vertices with $\delta(G) \geq (1 + 3c)n/2$, then $H \subset G$.

(Received March 04, 2013)

1090-05-350 **Frank Bauer, Paul Horn*** (phorn@math.harvard.edu), **Gabor Lippner** and **Yong Lin**. *Elliptic and parabolic gradient estimates on graphs*. Preliminary report.

Harnack inequalities relate the maximum and minimum values of eigenfunctions and, in the parabolic case, non-negative solutions to the heat equation. These are classically known in the manifold setting, but versions are known for graphs and it is known that a parabolic Harnack inequality on graphs holding is equivalent to the graph satisfying certain geometric conditions. In the non-negatively curved manifold case, stronger (local) gradient

estimates which imply the (global) Harnack inequalities are known. For graphs we know much less. In this talk, we give some progress in this direction. In particular we show some elliptic and parabolic gradient estimates for graphs under some suitable curvature conditions and discuss some related open questions. (Received March 04, 2013)

1090-05-353 **Elizabeth Lane-Harvard*** (emlane@jacks.sdstate.edu) and **Tim Penttila** (penttila@math.colostate.edu). *Constructions of Strongly Regular Graphs*. Preliminary report.

New strongly regular graphs are constructed. Some of those constructed have previously unknown parameters. The methods used involve the use of groups and of finite geometries. Joint work with Tim Penttila. (Received March 04, 2013)

1090-05-354 **George M. F. Brown*** (brownge@uwstout.edu), 205 Galloway Ct. #5, Menomonie, WI 54751. *Totally bipartite Leonard pairs and Leonard triples*.

Let \mathbb{K} denote a field and let V denote a vector space over \mathbb{K} of positive finite dimension. A Leonard pair is an ordered pair of linear transformations in $\text{End}(V)$ such that, for each transformation, there exists a basis for which the matrix representing that transformation is diagonal and the matrix representing the other transformation is irreducible tridiagonal. Related to a Leonard pair is a Leonard triple, an ordered triple of linear transformations in $\text{End}(V)$ such that, for each transformation, there exists a basis for which the matrix representing that transformation is diagonal and the matrices representing the other transformations are irreducible tridiagonal. A Leonard pair or Leonard triple is said to be totally bipartite whenever the diagonal entries of the tridiagonal matrices are all zero. We classify the totally bipartite Leonard pairs and Leonard triples up to isomorphism and show that any totally bipartite Leonard pair can be extended to a totally bipartite Leonard triple. (Received March 04, 2013)

1090-05-381 **Travis Johnston, Linyuan Lu and Kevin G. Milans*** (milans@math.wvu.edu). *Turán and Ramsey Results for Boolean Algebras*. Preliminary report.

Let $[n] = \{1, \dots, n\}$, and let X_0, X_1, \dots, X_n be disjoint subsets of the ground set $[n]$, all of which are nonempty except possibly X_0 . The *Boolean algebra* of dimension d generated by X_0, X_1, \dots, X_n is the family $\{X_0 \cup \bigcup_{i \in I} X_i : I \subseteq [d]\}$. A family of sets \mathcal{F} in $[n]$ is \mathcal{B}_d -free if it does not contain a Boolean algebra of dimension d .

Let $b(d, n)$ be the maximum size of a \mathcal{B}_d -free family in $[n]$. The Turán problem asks for bounds on $b(d, n)$. In 1999, Gunderson, Rödl, and Sidorenko showed that $b(d, n) \leq c_d n^{-1/2^d} \cdot 2^n$, where $c_d \sim (10d)^d$. Using the Lubell function, we show that c_d can be replaced by a constant. The same technique also yields a modest improvement to bounds on the corresponding Ramsey problem. Let $r(d, n)$ be the maximum number of colors k such that every k -coloring of subsets of $[n]$ contains a monochromatic Boolean algebra of dimension d . In the same paper, Gunderson, Rödl, and Sidorenko showed that $r(d, n) \geq cn^{1/2^d}$ for some constant c . We use the Lubell approach to prove $r(d, n) \geq 0.5(n+1)^{2/2^d}$. This is joint work with T. Johnston and L. Lu. (Received March 05, 2013)

1090-05-388 **Mike Develin and Matthew Macauley***, O-325 Martin Hall, Clemson, SC 29634-0975, and **Victor Reiner**. *Toric partial orders*.

We define toric partial orders, corresponding to regions of graphic toric hyperplane arrangements, just as ordinary partial orders correspond to regions of graphic hyperplane arrangements. Combinatorially, toric posets correspond to finite posets under the equivalence relation generated by converting minimal elements into maximal elements, or sources into sinks. There are natural toric analogues of many standard features of ordinary partial orders, such as chains, antichains, intervals, transitivity, Hasse diagrams, linear extensions, total orders, morphisms, and order ideals. Most of these only become apparent when one looks at these objects geometrically. We will also discuss how these arise naturally in the study of cyclic reducibility and conjugacy in Coxeter groups. (Received March 05, 2013)

1090-05-390 **Paul M Terwilliger***, Math Department, University of Wisconsin-Madison, 480 Lincoln Drive, Madison, WI 53706. *The universal Askey-Wilson algebra*.

The Askey-Wilson polynomials were introduced around 1985 and soon became a major topic in special functions. This topic became linked to representation theory around 1992 when A. Zhedanov introduced the Askey-Wilson algebra AW. The algebra AW is defined by generators and relations. The relations involve a scalar parameter q and a handful of extra scalar parameters. We introduce a central extension of AW, denoted Δ_q and called the universal Askey-Wilson algebra. Roughly speaking, up to normalization Δ_q is obtained from AW by interpreting the extra parameters as central elements in the algebra. By construction Δ_q involves no parameters besides q . In this talk we relate Δ_q to the following objects: (i) Leonard pairs and Leonard triples of QRacah type; (ii)

Q -polynomial distance-regular graphs; (iii) the modular group $\mathrm{PSL}_2(\mathbb{Z})$; (iv) the equitable presentation for the quantum group $U_q(\mathfrak{sl}_2)$; (v) the double affine Hecke algebra of type (C_1^V, C_1) . (Received March 05, 2013)

1090-05-397 **James Carraher**, University of Nebraska–Lincoln, and **Stephen G. Hartke*** (hartke@math.unl.edu), University of Nebraska–Lincoln. *Compatible circuits in 3-regular eulerian digraphs*.

Let G be an eulerian directed graph with a fixed edge coloring (not necessarily proper). A compatible circuit T is an eulerian circuit of G such that no consecutive edges in the circuit have the same color. Previously we characterized the existence of a compatible circuit when G has no vertices of outdegree 3, strengthening results of Fleischner and Isaak. We present results for the situation when G is regular of outdegree 3. (Received March 05, 2013)

1090-05-407 **Edward D. Hanson*** (hanson@math.wisc.edu), University of Wisconsin–Madison, Department of Mathematics, 480 Lincoln Dr., Madison, WI 53706. *The Tail Condition for Leonard Pairs*.

Roughly speaking, a Leonard pair can be thought of as an algebraic generalization of a Q -polynomial distance-regular graph. In this talk, we will discuss two characterizations of Leonard pairs that utilize the notion of a tail. This notion was originally introduced in the context of distance-regular graphs. (Received March 05, 2013)

1090-05-408 **Kathleen Nowak** and **Sung Y Song*** (sysong@iastate.edu), Department of Mathematics, Iowa State University, Ames, IA 50011-2064. *Small class association schemes obtained from cyclotomic classes*. Preliminary report.

We revisit the classical construction of small class association schemes using cyclotomic classes and Gaussian periods. We discuss some interesting properties of these schemes and their fusion and fission. (Received March 05, 2013)

1090-05-411 **Sarah R. Bockting-Conrad*** (bockting@math.wisc.edu). *Connections between $U_q(\mathfrak{sl}_2)$ and tridiagonal pairs*.

Let \mathbb{K} denote an algebraically closed field and let V denote a vector space over \mathbb{K} with finite positive dimension. Let A, A^* denote a tridiagonal pair of diameter $d \geq 1$ and let $\{V_i\}_{i=0}^d$ (resp. $\{V_i^*\}_{i=0}^d$) denote a standard ordering of the eigenspaces of A (resp. A^*). In an earlier paper, we associated with A, A^* a linear transformation $\Psi : V \rightarrow V$ such that $\Psi V_i \subseteq V_{i-1} + V_i + V_{i+1}$ and $\Psi V_i^* \subseteq V_0^* + V_1^* + \cdots + V_{i-1}^*$ for $0 \leq i \leq d$. One of the relations involving Ψ was reminiscent of a defining relation for the quantized enveloping algebra $U_q(\mathfrak{sl}_2)$. We explore this connection further. In doing so, we will give two natural $U_q(\mathfrak{sl}_2)$ -module structures for V and discuss how they are related. This leads to a number of interesting relations involving the operator Ψ and other operators associated with A, A^* . (Received March 05, 2013)

1090-05-420 **Linyuan Lu*** (lu@math.sc.edu), Columbia, SC 29063, and **Travis Johnston**. *Turán Problems on Non-uniform Hypergraphs*. Preliminary report.

Motivated by extremal poset problems, we consider extremal problems on non-uniform hypergraphs. A non-uniform hypergraph $H = (V, E)$ consists of a vertex set V and an edge set $E \subseteq 2^V$; the edges in E are not required to all have the same cardinality. The set of all cardinalities of edges in H is denoted by $R(H)$, the set of edge types. For a fixed hypergraph H , the Turán density $\pi(H)$ is defined to be $\lim_{n \rightarrow \infty} \max_{G_n} h_n(G_n)$, where the maximum is taken over all H -free hypergraphs G_n on n vertices satisfying $R(G_n) \subseteq R(H)$, and $h_n(G_n)$, the so called Lubell function, is the expected number of edges in G_n hit by a random full chain. In this talk, we will present some recent results as well as some open questions. (Received March 05, 2013)

1090-05-422 **Sarah Behrens***, University of Nebraska–Lincoln, **Catherine Erbes**, University of Colorado Denver, **Michael Ferrara**, University of Colorado Denver, **Stephen Hartke**, University of Nebraska–Lincoln, **Ben Reiniger**, University of Illinois Urbana-Champaign, **Hannah Spinoza**, University of Illinois Urbana-Champaign, and **Charles Tomlinson**, University of Nebraska–Lincoln. *Edge exchanges and realizations of k -graphic sequences*. Preliminary report.

A sequence of nonnegative integers is called k -graphic if it is the degree sequence of some simple k -uniform hypergraph. We extend a result of Kocay and Li to give a family of edge exchanges (an extension of two-switches) that is sufficient to transform any realization of a k -graphic sequence into any other realization of that sequence. However, the intermediate hypergraphs may have multi-edges. Examples will be provided to show edge exchanges that used to transform between realizations without multi-edges. (Received March 05, 2013)

1090-05-431 **Jason Williford*** (jwillif1@uwyo.edu), Department of Mathematics, College of Arts & Sciences, Dept. 3036. 1000 E. University, Laramie, WY 82071. *Subset bounds in association schemes and coherent configurations.*

An association scheme can be viewed as a generalization of a transitive group action on a finite set, where one substitutes certain local symmetry conditions in place of an actual group. A coherent configuration is an analogous generalization of a (possibly intransitive) group action on a finite set. Many objects in design theory, coding theory, finite geometry can be described as association schemes and/or coherent configurations. In Delsarte's thesis, he described necessary conditions for the existence of hypothetical subsets in association schemes. These conditions were in the form of a linear programming problem, and became known as the linear programming bound. This was then applied to obtain new bounds for codes and designs. When any of the inequalities in this bound is tight, one can recover certain regularity conditions between the subset and a fixed point. In this talk we will describe a generalization of this bound for coherent configurations, and give an analogous result when the bound is tight, including some examples. This is joint work with Sylvia Hobart. (Received March 05, 2013)

06 ► *Order, lattices, ordered algebraic structures*

1090-06-30 **John D. LaGrange** (lagrangej@lindsey.edu) and **Kyle A. Roy*** (royka@miamioh.edu). *Realizing zero-divisor graphs of posets.*

ABSTRACT. Let $\mathcal{P} = (P, \leq)$ be a poset with least element 0. Given a subset $S \subseteq P$, define $S^\wedge = \{x \in P \mid x \leq s \text{ for all } s \in S\}$. Any element of $Z(\mathcal{P}) = \{x \in P \mid \{x, y\}^\wedge = 0 \text{ for some } 0 \neq y \in P\}$ will be called a *zero-divisor* of \mathcal{P} . Then, the *zero-divisor graph* of \mathcal{P} , denoted by $\Gamma(\mathcal{P})$, is the (undirected) graph whose vertices are the elements of $Z(\mathcal{P}) \setminus \{0\}$ such that two vertices x and y are adjacent if and only if $\{x, y\}^\wedge = 0$. Earlier characterizations of zero-divisor graphs of finite Boolean rings are extended to classify zero-divisor graphs of (possibly infinite) posets. (Received January 17, 2013)

1090-06-46 **Clifford Bergman*** (cbergman@iastate.edu), Department of Mathematics, Ames, IA 50011. *Boolean Semilattices.* Preliminary report.

Let $\mathbf{S} = \langle S, \cdot \rangle$ be a semilattice. The *complex algebra* of \mathbf{S} is the algebra $\mathbf{S}^+ = \langle P(S), \cap, \cup, ', S, \cdot \rangle$ which is the Boolean algebra of all subsets of S augmented with the complex operation given by $X \cdot Y = \{x \cdot y : x \in X, y \in Y\}$. The variety of *Boolean semilattices* is generated by all such complex algebras.

The variety of Boolean semilattices is a very rich one, with an interesting arithmetic, many subvarieties and, of course, many open problems. In particular, it is unknown whether the variety is finitely based. In this talk I will survey what little we know about this variety and discuss some of the open problems. (Received January 28, 2013)

1090-06-384 **Graham Brightwell** (g.r.brightwell@lse.ac.uk), London School of Economics, Department of Mathematics, Houghton Street, London, WC2A 2AE, United Kingdom, and **Mitchel T. Keller*** (mitch.keller@unl.edu), University of Nebraska-Lincoln, Department of Mathematics, Lincoln, NE 68588. *Reversal Ratio and Linear Extension Diameter.*

The linear extension graph of a partially ordered set \mathbf{P} has as its vertex set the set of all linear extensions of \mathbf{P} . Two vertices are adjacent if and only if the corresponding linear extensions differ in the transposition of a single pair of incomparable elements. The linear extension diameter of \mathbf{P} is the diameter of its linear extension graph. In terms of linear extensions, the linear extension diameter is the maximum over all pairs of linear extensions L_1, L_2 of \mathbf{P} of the number of incomparable pairs appearing in opposite orders in L_1 and L_2 . We define the reversal ratio of \mathbf{P} to be its linear extension diameter divided by the total number of incomparable pairs.

This talk considers several extremal questions on the reversal ratio of posets. In particular, we demonstrate a family of posets with reversal ratio tending to zero as the number of points increases. We also examine bounds on the reversal ratio in terms of the dimension and width of a poset. Bounds in terms of width have proven particularly interesting and challenging, even for width 3. (Received March 05, 2013)

08 ► General algebraic systems

1090-08-214 **David Failing*** (dfailing@iastate.edu), Department of Mathematics, Iowa State University, Ames, IA 50011. *Structure Theory of CI-Groupoids of Bol-Moufang Type.*

A groupoid identity $p \approx q$ is of *Bol-Moufang type* if (i) the same 3 variables appear in p and q , (ii) one of the variables appears twice in p and q , (iii) the remaining two variables appear once in p and q , and (iv) the variables appear in the same order in p and q . Phillips and Vojtěchovský studied quasigroup and loop varieties defined by one additional identity of Bol-Moufang type, showing that there are exactly 26 and 14 such varieties, respectively.

Aided by Prover9/Mace4 and the Universal Algebra Calculator, we show that there are exactly eight varieties of commutative, idempotent groupoids defined by one additional identity of Bol-Moufang type. Five of them are congruence meet-semidistributive. We investigate the structure of the variety of commutative, idempotent groupoids satisfying $x(x(yz)) \approx (x(xy))z$, and show that it is the regularization of the variety of squags. We also show that every finite commutative, idempotent, distributive groupoid is a Płonka sum of quasigroups. (Received March 01, 2013)

11 ► Number theory

1090-11-246 **David J. Covert*** (covert@ums1.edu), University of Missouri - Saint Louis, Express Scripts Hall #349, One University Boulevard, Saint Louis, MO 63121. *Sums and products of smooth numbers.*

The Erdős-Szemerédi conjecture (also known as the sum-product conjecture) asks one to show that given any finite set of integers A , then the sumset $A + A = \{a + a' \mid a, a' \in A\}$ or the productset $A \cdot A = \{a \cdot a' \mid a, a' \in A\}$ is large. An integer x is called y -smooth if the largest prime factor of x is less than or equal to y . We show that a large class of smooth numbers satisfy the Erdős-Szemerédi conjecture. (Received March 02, 2013)

13 ► Commutative rings and algebras

1090-13-14 **Olivier Heubo-Kwegna*** (oheubokw@svsu.edu), 7400 Bay Road, Department of Mathematical Sciences, University Center, MI 48710. *On Local Star-Completely Integrally Closed Domains.*

Let \star be a star operation on an integral domain R . The domain R is a \star -completely integrally closed domain (or simply \star -CICD) if $(AA^{-1})^\star = R$ for all nonzero (fractional) ideals A of R . In this talk, we discuss \star -CICDs, especially the local case. We show that if the maximal ideal of a local \star -CICD is a \star -ideal, then R is \star -principal ideal domain. This will lead as consequences to various results on local Krull domains and local completely integrally closed domains. We also establish that any \star -CICD R is locally a PID when \star is induced by the localizations at prime ideals of R . (Received December 10, 2012)

1090-13-24 **John D. LaGrange*** (lgrangej@lindsey.edu), Lindsey Wilson College, Columbia, KY 42728. *Counting walks on zero-divisor graphs of finite reduced rings.* Preliminary report.

Let R be a finite reduced commutative ring. Define the *unrestricted zero-divisor graph* of R to be the graph $\Gamma_U(R)$ whose vertices are the elements of R such that two (not necessarily distinct) vertices r and s are adjacent if and only if $rs = 0$. Let n be a positive integer. Closed formulas for the number of walks in $\Gamma_U(R)$ of length n from r to s ($r, s \in R$) are given in terms of certain generalized Fibonacci numbers. For finite Boolean rings R , these results are used to address the problem of determining the number of closed walks of a given length in the subgraph $\Gamma(R)$ of $\Gamma_U(R)$ induced by the nonzero zero-divisors of R . (Received February 19, 2013)

1090-13-89 **Christopher Park Mooney*** (christopher-mooney@uiowa.edu), 14 MacLean Hall, Department of Mathematics, Iowa City, IA 52240. *τ -Factorization in Commutative Rings with Zero-Divisors.*

In this presentation, we discuss several methods of extending τ -factorization to commutative rings with zero-divisors, including the method of U-factorization. We present some of the main results from two papers which indicate the relationships between rings satisfying the various τ -finite factorization and τ -U-finite factorization properties. If time permits, we hope to briefly demonstrate an application using zero-divisor graph results. (Received February 19, 2013)

1090-13-95 **Sean Sather-Wagstaff*** (sean.sather-wagstaff@ndsu.edu). *Ascent properties for derived functors*. Preliminary report.

Given a flat local ring homomorphism $R \rightarrow S$, and two finitely generated R -modules M and N , we describe conditions under which the modules $\text{Tor}_i^R(M, N)$ and $\text{Ext}_R^i(M, N)$ have S -module structures that are compatible with their R -module structures. (Received February 20, 2013)

1090-13-105 **Richard Erwin Hasenauer*** (rhasenauer@eureka.edu). *Almost Dedekind domains and factorization*.

Let D be an almost Dedekind domain with maximal ideals $\text{Max}(D)$. Then for all maximal ideals M , we have that D_M is a Noetherian valuation domain. We piece together these local valuations, ν_M , by defining a map $N : D \rightarrow \prod \mathbb{N}_0$ with $b \mapsto (\nu_M(b))_{M \in \text{Max}(D)}$. The norm of an element b is a net. The collection of all norms (the normset) over D forms a monoid under componentwise addition. We show that P is a factorization property of D if and only if P is a factorization property of the normset. We also give examples of how the norm can be used to determine atomicity in almost Dedekind domains. (Received February 21, 2013)

1090-13-118 **Dan 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. *Zero divisors, torsion elements, and unions of chains of annihilators*.

It is well known that the set $Z(M)$ of zero divisors of a module M over a commutative ring R is a union of prime ideals. Likewise the set of torsion elements $T(M)$ is a union of prime submodules when M is not torsion. We are interested when $Z(M)$ or $T(M)$ is a union of prime ideals or prime submodules each of which is a union of annihilators such as a chain, directed union, etc of annihilators of single elements. (Received February 23, 2013)

1090-13-130 **David F. Anderson*** (anderson@math.utk.edu), Mathematics Department, University of Tennessee, Knoxville, TN 37996-1320, and **John D. LaGrange** (lagrangej@lindsey.edu), Division of Natural and Behavioral Sciences, Lindsey Wilson College, Columbia, KY 42728-1223. *The Abian order and semilattice of annihilator classes for a reduced commutative ring*.

Let R be a reduced commutative ring with $1 \neq 0$. Then R is a partially ordered set under the Abian order given by $x \leq y$ if and only if $xy = x^2$. Let R_E be the set of equivalence classes for the equivalence relation on R given by $x \sim y$ if and only if $\text{ann}_R(x) = \text{ann}_R(y)$. Then R_E is a commutative Boolean monoid with multiplication $[x][y] = [xy]$ and is thus partially ordered by $[x] \leq [y]$ if and only if $[xy] = [x]$. We will discuss R and R_E as both monoids and partially order sets, when R_E can be embedded in R , and when R is a semilattice and R_E is a lattice. (Received February 25, 2013)

1090-13-150 **Malik Bataineh*** (msbataineh@just.edu.jo), Jordan University of Science and Technology, P.O.Box 3030, Irbid, 22110, Jordan, and **Ala' Khazaaleh**. *Graded Primary Submodules Over Multiplication Modules*.

Let G be an abelian group with identity e , R be a G -graded commutative ring and M a graded R -module where all modules are unital. Various generalizations of graded prime ideals and graded submodules have been studied. For example, a proper graded ideal I is a graded weakly (resp; almost) prime ideal if $0 \neq ab \in I$ (resp; $ab \in I - I^2$) then $a \in I$ or $b \in I$. Also a proper graded submodule N of M is graded primary submodule if $rm \in N$, then either $m \in N$ or $r \in \sqrt{(N : M)}$.

Throughout this work, we define that a proper graded submodule is a graded weakly (resp; almost) primary submodule if $0 \neq rm \in N$ (resp; $rm \in N - (N : M)N$), then either $m \in N$ or $r \in \sqrt{(N : M)}$. We give some properties and characterizations of graded weakly (resp; almost) primary submodules. We show that graded weakly primary submodules enjoy analogs of many of the properties of prime submodules and primary submodules. (Received February 27, 2013)

1090-13-196 **Bruce Olberding*** (olberdin@nmsu.edu), Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88011. *Prüfer domains and the projective line*. Preliminary report.

Let F be a field, let D be a subring of F , and let Z be a subspace of the space of all valuation rings between D and F that have quotient field F . When $F \in Z$, then Z is a locally ringed space whose ring of global sections is $A = \bigcap_{V \in Z} V$. All rings between D and F that are integrally closed in F arise in such a way. Motivated by applications in areas such as multiplicative ideal theory and real algebraic geometry, a number of authors have

formulated criteria for when A is a Prüfer domain. We give geometric criteria for when A is a Prüfer domain that reduce this issue to questions of prime avoidance. (Received March 01, 2013)

1090-13-210 **Evan Houston*** (eghousto@uncc.edu) and **Mi Hee Park**. *A Partial Characterization of Noetherian Integral Domains Which Admit Only Finitely Many Star (Prime) Operations*. Preliminary report.

In previous work, we have shown that a Noetherian integral domain, not a field, admitting only finitely many star (prime) operations must have dimension one. We have also reduced to the local case. We now give an “almost complete” characterization of local Noetherian integral domains which admit only finitely many star operations under the assumption that the residue field is infinite. (Received March 01, 2013)

1090-13-259 **Shane P Redmond*** (shane.redmond@eku.edu), 521 Lancaster Ave., Richmond, KY 40475. *The cases for and against loops in the zero-divisor graphs of commutative rings*. Preliminary report.

For a commutative ring R with 1, the zero-divisor graph $\Gamma(R)$ takes as vertices the nonzero zero-divisors of R and defines an edge between distinct vertices x and y when $xy = 0$. This definition does not include an edge from a vertex x to itself, or a “loop,” indicating an element with $x^2 = 0$. Given a graph G that is the zero-divisor graph of some commutative ring, we discuss the algorithm that allows us to determine local rings R_1, \dots, R_n such that $\Gamma(R_1 \times \dots \times R_n) \cong G$ and shows these rings are unique up to factors R_i with isomorphic zero-divisor graphs. Corollaries of this result are used to make the case for and against the inclusion of loops in the zero-divisor graph and other graphical structures associated to commutative rings. (Received March 03, 2013)

1090-13-261 **David E. Dobbs*** (dobbs@math.utk.edu), Department of Mathematics, University of Tennessee, Knoxville, TN 37996-1320, **Gabriel Picavet** (gabriel.picavet@math.univ-bpclermont.fr), Laboratoire de Mathématiques, UMR6620 CNRS, Les Cezeaux, 24, Avenue des Landais, BP 80026, 63177 Aubiere CEDEX, France, and **Martine Picavet-L’Hermitte**, Laboratoire de Mathématiques, UMR6620 CNRS, Les Cezeaux, 24, Avenue des Landais, BP 80026, 63177 Aubiere CEDEX, France. *Transfer results for the FIP and FCP properties of ring extensions*. Preliminary report.

Let $R \subset S$ be (commutative) rings and $R \rightarrow R'$ a faithfully flat ring homomorphism. The possible transfer of the FCP and FIP properties is studied for the extensions $R \subset S$ and $R' \subset S' := R' \otimes_R S$. If $R' \subset S'$ is an FCP (resp., FIP) extension, then so is $R \subset S$. Applications are given in case $R' = R(X)$, the Nagata ring of R . Then $R \subset S$ has FCP if and only if $R(X) \subset S(X)$ has FCP. We characterize when $R(X) \subset S(X)$ has FIP. While $R \subset S$ has FIP whenever $R(X) \subset S(X)$ has FIP, the converse fails in general, notably for certain subintegral extensions, although it does hold if $R \subset S$ is integrally closed, seminormal, or subintegral with R a quasi-local ring with infinite residue field. For an extension $R \subset S$ with FCP, one has equality of $\ell[R, S]$ and $\ell[R(X), S(X)]$ (the suprema of lengths of chains of intermediate rings of $R \subset S$ and of $R(X) \subset S(X)$, respectively) in case $R \subset S$ is either integrally closed or infra-integral. (Received March 03, 2013)

1090-13-272 **Jim Coykendall*** (jim.coykendall@gmail.com), Department of Mathematics, North Dakota State University, Fargo, ND 58108-6050, and **Tridib Dutta**. *Some near-Noetherian conditions*.

In this talk, we will be considering a couple of properties that mimic the Noetherian property. Let $I \subseteq R$ be an ideal of a ring (commutative with identity). We say that I is of strong finite type (SFT) if there is a finitely generated ideal $B \subseteq I$ and a fixed positive integer N such that $x^N \in B$ for all $x \in I$. Additionally, we say that the ring R is SFT if every (prime) ideal of R has the SFT property. This property first surfaced in the 1973 work of J. Arnold on power series rings. In this context, it was shown that if R is not SFT, then $\dim R[[x]] = \infty$.

In a similar vein, we say that the ideal $I \subseteq R$ is of very strong finite type (VSFT) if there is a finitely generated ideal $B \subseteq I$ and a fixed positive integer N such that $I^N \subseteq B$, and we say that R is VSFT if every (prime) ideal is VSFT.

We investigate the interplay of these properties and their relationship to the Noetherianity that they emulate. (Received March 03, 2013)

1090-13-276 **Lars Winther Christensen*** (lars.w.christensen@ttu.edu) and **Oana Veliche**. *Local rings of embedding codepth 3*.

Let R be a local ring; by Cohen’s Structure Theorem its completion \widehat{R} is a quotient of a regular local ring Q . If the free resolution of \widehat{R} over Q has length 2, then its structure—and with it the homological nature of R —is determined by the Hilbert–Burch Theorem. For longer resolutions the structure is significantly harder to

describe, but for resolutions of length 3 a partial classification has been available for 25 years. I will discuss some recent progress towards completion of this classification. (Received March 03, 2013)

1090-13-301 **Amanda Croll*** (s-acroll1@math.unl.edu). *Periodic modules over Gorenstein local rings*. Preliminary report.

In 1990, Avramov posed the following problem: characterize the rings that have a periodic module, which is defined to be a module with a periodic minimal free resolution. It is proved that a complete Gorenstein local ring has such a module if and only if there is nontrivial torsion in a certain $\mathbb{Z}[t, t^{-1}]$ -module associated to the ring. This module, which we denote $J_R(t)$, is the free $\mathbb{Z}[t, t^{-1}]$ -module on the isomorphism classes of finitely generated R -modules modulo relations reminiscent of those defining the Grothendieck group of R . The main result is a structure theorem for $J_R(t)$ when R is a complete Gorenstein local ring; the link between torsion and existence of a periodic module is a corollary. (Received March 04, 2013)

1090-13-304 **William Heinzer, IN, K Alan Loper*** (loper.4@osu.edu), Ohio State University, 1179 University Drive, Newark, OH 43055, and **Bruce Olberding** and **Hans Schoutens**. *Chains of quadratic transforms of a regular local ring*. Preliminary report.

Abhyankar demonstrated in 1956 that if D is a two-dimensional regular local ring then the union of a chain of quadratic transforms of D is always a valuation domain. In 1973 David Shannon proved that if D is a regular local ring of dimension greater than two then the union of a chain of quadratic transforms may fail to be a valuation ring. In this talk we investigate what is true about the non-valuation unions of such chains. (Received March 04, 2013)

1090-13-316 **Ashley Rand*** (rand@math.utk.edu). *Multiplicative Subsets of Atoms*. Preliminary report.

A reduced, cancellative, torsion-free, commutative monoid M can be embedded in an integral domain R , where the atoms (irreducible elements) of M correspond to a subset of the atoms of R . This fact was used by J. Coykendall and B. Mammenga to show that for any reduced, cancellative, torsion-free, commutative monoid M , there exists an integral domain R with atomic factorization structure isomorphic to M . More generally, we show that any “nice” subset of the atoms of R can be realized as the set of atoms of an integral domain T which contains R . We will also give several applications of this result. (Received March 04, 2013)

1090-13-319 **Jim Coykendall** and **Brandon Goodell***, brandon.goodell@ndsu.edu. *A Homological Approach to Factorization*.

Factorization information in an integral domain, D , is encoded in the partial ordering on its group of divisibility, $G(D)$. We develop a particular sequence of order-preserving epimorphisms naturally admitted by a group of divisibility. From this sequence of maps we obtain a wealth of information. In particular, we obtain cochain complexes that yield cohomological information. We provide examples for which interesting cohomological phenomena such as torsion corresponds to interesting factorization behavior such as quasi-atomicity. (Received March 04, 2013)

1090-13-323 **Sean Sather-Wagstaff** and **Richard Wicklein*** (richard.wicklein@ndsu.edu). *Codualizing Modules And Complexes*. Preliminary report.

Let R be a commutative, noetherian ring. A finitely generated R -module C is said to be semidualizing if $\text{Ext}_R^i(C, C) = 0$ for all $i > 0$ and $R \xrightarrow{\cong} \text{Hom}_R(C, C)$. When R is local, an artinian R -module T is said to be quasidualizing if $\text{Ext}_R^i(T, T) = 0$ for all $i > 0$ and $\widehat{R} \xrightarrow{\cong} \text{Hom}_R(T, T)$. Using the notion of I -cofiniteness, we introduce a unifying notion that recovers each of the above notions as special cases. (Received March 04, 2013)

1090-13-324 **Thomas G Lucas*** (tglucas@uncc.edu). *Localizing Global Properties to Individual Maximal Ideals*.

We consider three related questions. Q_1 : Given a global property \mathbf{G} of a domain R , what does a particular maximal ideal M of R “know” about the property with regard to the ideals $I \subseteq M$ and elements $t \in M$? Suppose \mathbf{P} is such a property corresponding to \mathbf{G} . Q_2 : If each maximal ideal knows it satisfies \mathbf{P} , does R have the corresponding global property \mathbf{G} ? Q_3 : If at least one maximal ideal knows it satisfies property \mathbf{P} for \mathbf{G} , does R have the global property \mathbf{G} ? We assume that if $I \subseteq M$, then M can tell when a particular element $t \in M$ is contained in I and when it isn't. Thus for a pair of ideals I and J contained in M , M knows when $I \subseteq J$. In addition, this allows M to understand the intersection of ideals it contains. In some cases, if a single maximal ideal knows \mathbf{P} , then R will satisfy \mathbf{G} . For example, there are such \mathbf{P} s for $\mathbf{G} \in \{\text{PIDs, Noetherian domains, Domains with ACCP, Domains with finite character}\}$. (Received March 04, 2013)

1090-13-334 **Jason Robert Juett*** (jason-juett@uiowa.edu), 808 Oakcrest St Apt 1, Iowa City, IA 52246. *An atomic domain that is not a comaximal factorization domain.*

This presentation will give a review of some basic facts about comaximal factorization of elements of an integral domain, eventually building up to the construction of the first example of an atomic domain that is not a comaximal factorization domain. (Received March 04, 2013)

1090-13-340 **Saeed Nasseh*** (saeed.nasseh@ndsu.edu), Department of Mathematics, North Dakota State University, Fargo, ND 58108, and **Sean Sather-Wagstaff** (sean.sather-wagstaff@ndsu.edu), Department of Mathematics, North Dakota State University, Fargo, ND 58108. *Cohen factorizations and applications.*

We discuss "weakly functorial properties" of Cohen factorizations. We also use Cohen factorizations to investigate the structure of quasi-deformations of local rings. (Received March 04, 2013)

1090-13-359 **Claudia Miller, Hamid Rahmati*** (hrahmati@miamioh.edu) and **Janet Striuli**. *Duality for Koszul homology over Gorenstein rings.*

Over a Gorenstein ring, if an ideal satisfies the property that all its nonzero Koszul homologies are Cohen-Macaulay, then by a classical result, due to Herzog, the Koszul homology algebra satisfies Poincaré duality. We will discuss a slightly weaker version of this duality that holds for all ideals of a Gorenstein. We will also give some applications of this duality. This is joint work with Claudia Miller and Janet Striuli. (Received March 04, 2013)

1090-13-361 **Mark E Walker*** (mwalker5@math.unl.edu), Dept. of Mathematics, 203 Avery Hall, University of Nebraska, Lincoln, NE 68588. *A curved perspective on complete intersections.* Preliminary report.

This talk will concern recent developments in the study of modules over complete intersection rings growing out of the connection with the theory of curved modules over curved algebras. The codimension one case of this connection involves the theory of matrix factorizations. (Received March 04, 2013)

1090-13-374 **Daniel Heranadez, Luis Nunez-Betancourt, Emily Witt and Wenliang Zhang*** (wzhang15@unl.edu), 203 Avery Hall, University of Nebraska, Lincoln, NE 68588. *F-pure thresholds of quasi-homogeneous polynomials.*

The F -pure threshold of a polynomial over a field of characteristic p is a positive rational number in $(0, 1]$ that measures the singularity of the hypersurface defined by the polynomial. In this talk, I will discuss some recent developments regarding the connections between F -pure thresholds of quasi-homogeneous polynomials and their counterparts in characteristic 0. (Received March 04, 2013)

1090-13-386 **Silvia Saccon*** (ssaccon@math.arizona.edu), Department of Mathematics, The University of Arizona, Tucson, AZ 85721. *Ranks and decompositions of modules.*

Given a commutative ring R and a class \mathcal{C} of R -modules closed under isomorphism, finite direct sums, and direct summands, one can ask whether every module in \mathcal{C} decomposes uniquely as a direct sum of indecomposable modules in \mathcal{C} . We restrict our attention to one-dimensional Noetherian local rings (R, \mathfrak{m}) whose \mathfrak{m} -adic completion is reduced, and we study the direct-sum behavior of maximal Cohen-Macaulay modules over R . Such behavior is captured by the monoid of isomorphism classes of maximal Cohen-Macaulay modules (together with $[0_R]$) with operation induced by the direct sum. To understand this monoid, it suffices to determine which ranks occur for indecomposable modules. (The *rank* of an R -module M is the tuple consisting of the vector-space dimensions of M_P over R_P , where P ranges over the minimal prime ideals of R .) While it is known which ranks occur for indecomposable modules when the ring has finite Cohen-Macaulay type, the question is still open when the ring has infinite Cohen-Macaulay type. In this talk, we will discuss progress made in this direction, and describe the direct-sum behavior of modules when the ring has *infinite* Cohen-Macaulay type. (Received March 05, 2013)

1090-13-389 **David A. Jorgensen*** (djorgens@uta.edu), Department of Mathematics, University of Texas at Arlington, Box 19408, Arlington, TX 76019. *On support varieties over complete intersections.*

The notion of support variety is a means of encoding homological behavior of a module over a local ring into an algebraic variety. There is well-developed theory of support varieties for modules over complete intersection local rings. We will discuss this theory, give a survey of old results, and give some new results. (Received March 05, 2013)

1090-13-395 **Paul Baginski*** (pbaginsk@smith.edu), Smith College, Department of Mathematics and Statistics, 44 College Lane, Northampton, MA 01063, and **George J Schaeffer**, University of California, Los Angeles. *Length Multiset-Complete Krull Monoids.*

Let H be a Krull monoid or Krull domain, let G be its divisor class group, and let $G_0 \subset G$ be the classes containing prime divisors. It is well known that each nonunit $x \in H$ has only finitely many factorizations into irreducibles. If $x = a_1 \cdots a_n$ is a factorization \mathbf{z} of x into irreducibles, the length of this factorization is $n = |\mathbf{z}|$. We elaborate upon the well-studied set $\mathcal{L}(x)$ of factorization lengths of x to account for the number of factorizations of a given length. If $Z(x)$ is the set of factorizations of x (a subset of the free monoid over the irreducibles of H), then the length multiset of x , denote $\mathcal{LM}(x)$, is the multiset $\{ \{ |\mathbf{z}| : \mathbf{z} \in Z(x) \} \}$.

Kainrath has shown that if the Krull monoid H has infinite class group G and $G_0 = G$, then for any finite multiset S on $\mathbb{N} \setminus \{1\}$, there is an $x \in H$ with $\mathcal{LM}(x) = S$. Kainrath's proof was nonconstructive. In this talk we will give the background on Kainrath's result and illustrate a constructive proof for $G = \mathbb{Z}$. We will also discuss recent work to extending Kainrath's result to Krull monoids with $G = \mathbb{Z}$ but G_0 a proper subset of \mathbb{Z} . (Received March 05, 2013)

1090-13-427 **William Thomas Sanders*** (wsanders@math.ku.edu). *Semidualizing Modules Over Rings of invariants.*

Given an Noetherian ring R , a finitely generated R module C is called semidualizing if $\text{Ext}_R^{>0}(C, C) = 0$ and the natural map $R \rightarrow \text{Hom}_R(C, C)$ is an isomorphism. Examples of semidualizing modules over R include R itself and the canonical module of R , if it exists. It is wondered in what cases that the aforementioned examples are the only semidualizing modules that exist over a ring R .

In this talk, I will define semidualizing modules and tell what progress has been made on this question. In particular, I will talk about the case where R is the ring of invariants of a finite group acting on a polynomial ring. (Received March 05, 2013)

1090-13-434 **Alina Florescu*** (alina-florescu@uiowa.edu). *Generalized Integer Factorizations.* Preliminary report.

D. D. Anderson and A. Frazier introduced a general theory of factorization in *On a general theory of factorization in integral domains*, Rocky Mountain J. Math. vol. 41, no. 3 (2011), 663-705.

Fixing a non-negative integer n , a τ_n -factorization of an integer a ($\neq -1, 0, 1$) is a factorization of the form

$$a = a_1 a_2 \dots a_k \quad \text{or} \quad a = (-1) a_1 a_2 \dots a_k$$

where $a_1 \equiv a_2 \equiv \dots \equiv a_k \pmod{n}$ and a_i are non-units. A reduced τ_n -factorization of a is a τ_n -factorization of the first type, $a = a_1 a_2 \dots a_k$, with $a_1 \equiv a_2 \equiv \dots \equiv a_k \pmod{n}$ and $a_i \neq \pm 1$. We will compare τ_n -factorizations of the integers, reduced τ_n -factorizations and τ_n -factorizations of the natural numbers and discuss how the Fundamental Theorem of Arithmetic extends to these factorizations. (Received March 06, 2013)

14 ► Algebraic geometry

1090-14-23 **Elena S Dimitrova*** (edimit@clemsun.edu), O-303 Martin Hall, Clemson University, Clemson, SC 29634. *Data characterization and identification for network inference.*

Recently polynomial dynamical systems (PDSs) have been used as models of gene regulatory networks (GRNs). An advantage of using PDSs as models is that the set of all models that "fit" a given data set for a GRN admits an algebraic structure, similar to a vector space. However, few results other than a criterion by L. Robbiano have been published on the amount and type of data necessary for identifying PDS models and there are no methods for generating the specific data sets which would unambiguously identify the network. In this talk, necessary and sufficient criteria will be presented for a data set to uniquely identify PDSs of GRNs using tools from computational algebra and algebraic geometry. (Received January 10, 2013)

1090-14-62 **F Thompson*** (fjthomps@oakland.edu), Fred Thompson, 811 N Blair, Royal Oak, MI 48067, and **L Beshaj** (beshaj@oakland.edu). *Hyperelliptic curves of genus 3 with extra involutions.*

In this talk we study genus 3 hyperelliptic curves with extra involutions. The space \mathcal{S} of such curves is a 3-dimensional irreducible algebraic subvariety of the hyperelliptic moduli. We determine the equation of this space in terms of the $Gl(2, k)$ -invariants of binary octavics and find a birational parametrization of \mathcal{S} . We also compute all possible loci of curves for all possible automorphism group G . (Received February 09, 2013)

1090-14-127 **Ivan Horozov*** (horozov@math.wustl.edu), Department of Mathematics, Washington University in St. Louis, One Brookings Drive, Campus Box 1146, Saint Louis, MO 63130.
Reciprocity Laws on Algebraic Surfaces via Iterated Integrals.

I will present a construction of the Parshin symbol and of a new 4-function local symbol via iterated integrals. First, I will recall what iterated integrals are. After defining the local symbols, I will present a proof of two types of reciprocity laws that each of the local symbols satisfy. I have essentially two different proof of the reciprocity laws. The first proof is based on iterated integrals and the second uses K-theory. The two approaches lead to the same Parshin symbol and essentially the same 4-function symbol with a difference up to a sign. (Received February 25, 2013)

1090-14-198 **Mlagros Izquierdo*** (milagros.izquierdo@liu.se), Department of Mathematics, Linköping University, SE-58183 Linköping, Sweden, and **Antonio F Costa** (acosta@mat.uned.es) and **Gabriel Bartolini** (gabriel.bartolini@gmail.com).
Automorphisms Groups of p-gonal Riemann Surfaces.

A cyclic p -gonal Riemann surface is a surface admitting a regular cyclic p -gonal covering on the Riemann sphere. The covering is called the p -gonal morphism, and it is wellknown that it is unique if the genus of the surface is at least $(p - 1)^2 + 1$. The Riemann sphere can be seen as the quotient of the Riemann surface by a cyclic group of automorphisms: the group of p -gonality. We will see that a group of automorphisms of a cyclic p -gonal Riemann surface, p an odd prime number, is a split extension of the group of p -gonality by a finite spherical group. (Received March 01, 2013)

1090-14-245 **Brian Harbourne*** (bharbourne1@unl.edu), Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588-3012. *Resurgences: the road ahead and a look back.*

I will survey recent work and open problems related to resurgences of homogeneous ideals in polynomial rings. (Received March 02, 2013)

1090-14-280 **Ernst Kani*** (kani@mast.queensu.ca), Department of Mathematics and Statistics, Queen's University, 99 University Avenue, Kingston, Ontario K7L 3N6, Canada.
Generalized Humbert Schemes and Intersections of Humbert Surfaces. Preliminary report.

In order to study the components of the intersection of two Humbert surfaces in the moduli space A_2 of principally polarized abelian surfaces, it is useful to introduce more generally the concept of a *generalized Humbert scheme*: this is a certain subscheme $H_g(q) \subset A_g$ which is attached to a positive definite integral quadratic form q .

In this lecture we present various properties of the $H_2(q)$'s and explain how the arithmetic theory of quadratic forms can be used to obtain results about the geometry of the $H_2(q)$'s and also information about the components of the intersection of two Humbert surfaces. Of particular interest here are those Humbert surfaces which are closely related to the Hurwitz spaces of genus 2 covers of elliptic curves. (Received March 04, 2013)

1090-14-352 **Domenico D'Alessandro** and **Alexander A Voronov*** (voronov@umn.edu), School of Mathematics, University of Minnesota, 206 Church St SE, Minneapolis, MN 55455-0488.
The Batalin-Vilkovisky Formalism and Cohomology of Moduli Spaces. Preliminary report.

We use the Batalin-Vilkovisky formalism to give a new proof of Costello's theorem on the existence and uniqueness of solution to the Quantum Master Equation. We also make a physically motivated conjecture on the cohomology of moduli spaces. (Received March 04, 2013)

1090-14-373 **Jennifer Paulhus*** (paulhusj@grinnell.edu). *Computing branching data and decomposing Jacobian varieties.*

In this talk we will discuss recent updates made to a program of Breuer's which computes the automorphism group, G , of any Riemann surface, X , of genus up to 48. The program now provides data in GAP or Magma and includes branching data for the covering from X to X/G for each surface. We will describe the new functionality and also discuss some recent results, obtained from this data, on decomposing Jacobian varieties of curves. (Received March 04, 2013)

1090-14-376 **Andreas Malmendier*** (andreas.malmendier@colby.edu), 5835 Mayflower Hill, Waterville, ME 04901, and **Ken Ono**. *Donaldson invariants and mock modular forms.*

In the past 30 years gauge theory has been proven to be an important tool in the investigation of four-dimensional manifolds and has played a major role in new developments in both mathematics and physics. In physics, the moduli space of vacua for the topological $N = 2$ supersymmetric pure gauge theories with gauge group $SU(2)$ or $SO(3)$ is the universal elliptic curve for the modular group of level 2. Moreover, the supersymmetric gauge theory associates to each four-manifold a not necessarily holomorphic modular form of level two. I will explain why for

the complex projective plane this modular form is a mock theta function - in fact, it is one of the examples listed in Ramanujan's letter to Hardy to undermine a notoriously obscure definition. In joint work with Ken Ono, we then proved that its cusp contributions are the Donaldson invariants of $\mathbb{C}P^2$, a conjecture made by Moore and Witten. Time permitting, I will also sketch how this computation generalizes to other Hirzebruch surfaces. (Received March 05, 2013)

1090-14-383 **Sara Gharahbeigi*** (gharahbeigis@missouri.edu), 320A Math Science Building, Columbia, MO 65211. *Regularity of general rational curves on hypersurfaces.*

We prove a maximal rank statement for rational curves on hypersurfaces. As a result, we get that regularity index for general smooth rational curves on hypersurfaces is as small as possible. (Received March 05, 2013)

1090-14-402 **Ravindra Girivaru*** (girivarur@ums1.edu) and **Amit Tripathi.** *Extension theorems for vector bundles.*

Given a smooth ample hyperplane section Y of a smooth projective variety X , we will describe some results on extending a bundle on Y to a bundle on a Zariski open neighbourhood of Y in X . As a corollary, we obtain a generalisation of the Noether-Lefschetz theorem to higher rank bundles. (Received March 05, 2013)

1090-14-416 **Tony Shaska*** (shaska@oakland.edu). *Decomposition of superelliptic Jacobians.*

We study Jacobians of algebraic curves and their decompositions induced by the automorphisms of the curve. For algebraic curves \mathcal{X} of genus $g \geq 2$ with large automorphism group G (i.e, $|G| \geq 4(g-1)$) such decompositions of Jacobians $J(\mathcal{X})_W$ are determined for a fixed polarization W , based on the G -action on the symplectic basis of $J(\mathcal{X})_W$. We focus on superelliptic curves for any genus $g \geq 2$ and any automorphism group. (Received March 05, 2013)

15 ► Linear and multilinear algebra; matrix theory

1090-15-17 **Judi J McDonald*** (jmcDonald@math.wsu.edu). *The Essence of Nonnegativity for Matrices.*

Nonnegative and eventually nonnegative matrices are important in many applications. The essence of nonnegativity is two-fold – it depends on the spectrum and the basis of eigenvectors. In this talk we will look at the relationship between spectra and bases for nonnegative and eventually nonnegative matrices. (Received December 24, 2012)

1090-15-35 **Travis Peters*** (tpeters319@gmail.com). *Positive semidefinite maximum nullity and zero forcing number.*

The zero forcing number $Z(G)$ is used to study the maximum nullity/minimum rank of the family of symmetric matrices described by a simple, undirected graph G . We study the positive semidefinite zero forcing number $Z_+(G)$ and some of its properties. In particular, we determine the maximum positive semidefinite nullity and positive semidefinite zero forcing number for a number of graph families appearing in the AIM minimum rank graph catalog. (Received January 19, 2013)

1090-15-52 **Judith J McDonald** and **Pietro Paparella*** (ppaparella@gmail.com), Department of Mathematics, Washington State University, PO Box 643113, Pullman, WA 99164, and **Michael J Tsatsomeros.** *Matrix roots of nonnegative and eventually nonnegative matrices.*

Eventually nonnegative matrices are real matrices whose powers become and remain nonnegative. As such, eventually nonnegative matrices are a fortiori matrix roots of nonnegative matrices, which motivates us to study the matrix roots of nonnegative matrices. Using classical matrix function theory and Perron-Frobenius theory, we characterize, classify, and describe in terms of the real Jordan canonical form the p th-roots of nonnegative and eventually nonnegative matrices. (Received February 06, 2013)

1090-15-69 **Nathan J Warnberg*** (warnberg@iastate.edu), 809 Clark Ave, Ames, IA 50010. *Positive Semidefinite Propagation Time.* Preliminary report.

Positive semidefinite (PSD) zero forcing on a simple undirected graph G is based on the following color change rule: Let $B \subseteq V(G)$ be colored black and the rest of the vertices be colored white. Let C_1, C_2, \dots, C_k be the connected components of $G - B$. For any black vertex $b \in B \cup C_i$ that has exactly one white neighbor $w \in B \cup C_i$, change the color of w to black. A minimum PSD zero forcing set is a set of black vertices of minimum cardinality that color the entire graph black. The PSD propagation time of a PSDZFS B of graph G is the minimum number

of iterations of the color change rule needed to force all vertices of G black, starting with the vertices in B black. Minimum and maximum PSD propagation time are taken over all minimum PSD zero forcing sets. Extreme propagation times $|G| - 1$, $|G| - 2$, will be discussed as well as graph family results. (Received February 14, 2013)

1090-15-77 **Chi-Kwong Li*** (ckli@math.wm.edu), Jones Hall, Department of Mathematics, College of William and Mary, Williamsburg, VA 23187. *Factorization of matrices into matrices with prescribed zero and nonzero patterns.*

We discuss problems on factorization of matrices into matrices with prescribed zero and nonzero patterns arising in different areas including matching and sorting algorithms, numerical linear algebra, and quantum computing. (Received February 17, 2013)

1090-15-83 **Plamen S Koev*** (koev@math.sjsu.edu), 1 Washington Sq, San Jose, CA 95192. *Variation-diminishing properties and bidiagonal decompositions of eigenvector matrices of totally positive matrices.*

We will present a full characterization of the eigenvector matrices of the totally positive (TP) matrices. This characterization is in terms of the bidiagonal decompositions of the eigenvector matrices themselves.

Namely, if a matrix and its resigned converse are both lowerly totally positive, then this matrix is an eigenvector matrix of some TP matrices and vice versa.

This condition is easy to check in practice and is very useful in theory in practice:

1. It allows one to establish the sign pattern of the eigenvector matrices through simple and straightforward arguments using bidiagonal decompositions.

2. It allows for a simple check to verify if a given matrix is an eigenvector matrix of a TP matrix.

3. It allows one to generate such eigenvector matrices without the need to run an eigenvalue algorithm on a TP matrix. (Received February 18, 2013)

1090-15-97 **Juan M. Pena*** (jmpena@unizar.es), Departamento de Matematica Aplicada, Universidad de Zaragoza, 50009 Zaragoza, Spain. *Computations with some classes of matrices related to P-matrices.*

A square matrix is called a P-matrix if all its leading principal minors are positive. Subclasses of P-matrices very important in applications are the nonsingular totally nonnegative matrices and the nonsingular M-matrices. Other classes of P-matrices used for eigenvalue localization are also presented. We also present some recent results and applications of the following two classes of matrices: sign-regular matrices (which contains the class of totally nonnegative matrices) and H-matrices (which contains the class of M-matrices). Let us recall that nonsingular H-matrices are, in fact, strictly diagonally dominant matrices up to a column scaling. For diagonally dominant matrices and some subclasses of nonsingular totally nonnegative matrices, accurate methods for computing their singular values, eigenvalues or inverses have been obtained, assuming that adequate natural parameters are provided. We present some recent extensions of these methods to other related classes of matrices. (Received February 21, 2013)

1090-15-101 **Jason J. Moliterno*** (moliternoj@sacredheart.edu), Department of Mathematics, Sacred Heart University, 5151 Park Avenue, Fairfield, CT 06825-1000. *The Algebraic Connectivity of Planar Graphs.*

The Laplacian matrix for a graph on n vertices labeled $1, \dots, n$ is the $n \times n$ matrix $L = [\ell_{i,j}]$ in which ℓ_{ii} is the degree of vertex i and ℓ_{ij} , for $i \neq j$, is -1 if vertices i and j are adjacent and 0 otherwise. Since L is positive semidefinite and singular, we can order the eigenvalues $0 = \lambda_1 \leq \lambda_2 \leq \dots \leq \lambda_n$. The eigenvalue λ_2 is known as the algebraic connectivity of a graph as it gives a measure of how connected the graph is. In this talk, we derive an upper bound on the algebraic connectivity of planar graphs and determine all planar graphs in which the upper bound is achieved. If time permits, we will extend these results in two directions. First, we will derive smaller upper bounds on the algebraic connectivity of planar graphs with a large number of vertices. Secondly, we will consider upper bounds on the algebraic connectivity of a graph as a function of its genus. (Received February 21, 2013)

1090-15-106 **Shahla Nasserar*** (shahla.nasserar@uregina.ca), Department of Mathematics and Statistics, University of Regina, Regina, SK S4S 0A2, Canada. *Inequalities on Totally Nonnegative Matrices.*

A matrix is called totally nonnegative (positive) if all of the minors of any order are nonnegative (positive). Such matrices are denoted by TN (TP) and have been of interest to many researchers for nearly a century. For the set of TN matrices of the same order, several inequalities such as Bruhat, checkerboard, and compound inequalities

have been studied. I intend to survey some of these inequalities in the context of TN matrices and will present a number of their properties and applications. (Received February 22, 2013)

1090-15-109 **Shaun M Fallat*** (shaun.fallat@uregina.ca), Department of Mathematics and Statistics, University of Regina, Regina, SK S4N 5C3, Canada, and **Lon H Mitchell** (lonmitchell@gmail.com), Mathematical Reviews, Ann Arbor, MI 48103. *Colin de Verdière Parameters of Chordal Graphs.*

The Colin de Verdière parameters, μ and ν , are defined to be the maximum nullity of certain real symmetric matrices associated with a given graph. In this talk, I will show how both of these parameters can be calculated for chordal graphs. For ν the calculation is based solely on maximal cliques, while for μ the calculation depends on split subgraphs. (Received February 22, 2013)

1090-15-110 **Craig Erickson*** (craig@iastate.edu), Department of Mathematics, 396 Carver Hall, Ames, IA 50011. *Sign patterns that require eventual exponential nonnegativity.*

A real square matrix A is eventually exponentially nonnegative if there exists a positive real number t_0 such that for all $t \geq t_0$, e^{tA} is an entrywise nonnegative matrix where $e^{tA} = \sum_{k=0}^{\infty} \frac{t^k A^k}{k!}$. A sign pattern \mathcal{A} is a matrix having entries in $\{+, -, 0\}$ and its qualitative class is the set of all real matrices A for which $\text{sgn}(A) = \mathcal{A}$. A sign pattern \mathcal{A} requires eventual exponential nonnegativity if every matrix in the qualitative class of \mathcal{A} is eventually exponentially nonnegative. In this talk, we discuss the structure of sign patterns that require eventual exponential nonnegativity. (Received February 22, 2013)

1090-15-112 **Kevin N. Vander Meulen*** (kvanderm@redeemer.ca), Department of Mathematics, Redeemer University College, 777 Garner Road, Ancaster, Ontario L9K 1J4, Canada. *Techniques for Verifying Inertially Arbitrary Patterns.*

There are two known techniques that have been developed to show a matrix pattern is spectrally arbitrary, namely the nilpotent-Jacobian method and the nilpotent-centralizer method. We describe generalizations of both techniques that help show that certain patterns which are not spectrally arbitrary are nevertheless inertially arbitrary. Includes work with M.Cavers, C. Garnett, I.-J. Kim, D. Olesky, and P. van den Driessche. (Received February 22, 2013)

1090-15-113 **In-Jae Kim*** (in-jae.kim@mnsu.edu), 273 Wissink Hall, Mankato, MN 56001. *Eventual Positivity in Multivariate Data Analysis.* Preliminary report.

In this talk, implications of eventual positivity in multivariate data analysis will be discussed. (Received February 22, 2013)

1090-15-134 **Pauline van den Driessche*** (pvdd@math.uvic.ca). *Refined Inertia of Sign Pattern Matrices and Applications to Dynamical Systems.*

A sign pattern matrix S has entries from $\{+, -, 0\}$ and defines an associated sign pattern class $Q(S)$ of real matrices. For a real $n \times n$ matrix A , the refined inertia of A is the 4-tuple of nonnegative integers $ri(A) = (n_+, n_-, n_0, 2n_p)$, where n_+, n_- is the number of eigenvalues with positive, negative real part, n_0 is the number of zero eigenvalues, $2n_p$ is the number of nonzero imaginary eigenvalues, and $n_+ + n_- + n_0 + 2n_p = n$. The refined inertia of sign pattern S is $\{ri(A) : A \in Q(S)\}$. The focus of this talk is on sign patterns that require or allow the three particular refined inertias $\{(0, n, 0, 0), (0, n - 2, 0, 2), (2, n - 2, 0, 0)\}$, as these may signal the onset of Hopf bifurcation in associated dynamical systems. Some results for families of sign patterns are given, and applied to some sign patterns from specific dynamical systems, some of which have magnitude restrictions. (Received February 25, 2013)

1090-15-166 **Keivan Hassani Monfared*** (k1monfared@gmail.com), 1000 E University Ave. Dept 3036, Laramie, WY 82071, and **Bryan L Shader** (bshader@uwyo.edu), 1000 E University Ave. Dept 3036, Laramie, WY 82071. *Construction of real symmetric matrices with prescribed second order interlacing sets of eigenvalues and graph.*

Let $\lambda_1 < \dots < \lambda_n$, $\tau_1 < \dots < \tau_{n-2}$ be $2n - 2$ real numbers that satisfy strict second order Cauchy interlacing inequalities $\lambda_i < \tau_i < \lambda_{i+2}$ and a nondegeneracy condition $\lambda_{i+1} \neq \tau_i$. Given a connected graph G on n vertices where vertices 1, 2 are adjacent, it is proven that there is a real symmetric matrix A with eigenvalues $\lambda_1, \dots, \lambda_n$, and eigenvalues of $A(\{1, 2\})$ are $\tau_1, \dots, \tau_{n-2}$, such that graph of A is G , provided some necessary conditions are satisfied. (Received February 27, 2013)

1090-15-185 **Louis Deaett*** (louis.deaett@quinnipiac.edu). *New perspectives on Rosenfeld's theorem*. Preliminary report.

A 1991 result of Moshe Rosenfeld shows that if G is connected and triangle-free on n vertices, then its minimum semidefinite rank must be at least $n/2$. This talk will explore a new proof of Rosenfeld's result, disprove a previously conjectured generalization, and present an analogous result for graphs with girth at least 5. (Received February 28, 2013)

1090-15-186 **Adam Berliner*** (berliner@stolaf.edu), MSCS Department, 1520 St. Olaf Ave., Northfield, MN 55057, and **Minerva Catral, Leslie Hogben, My Huynh, Kelsey Lied** and **Michael Young**. *Minimum rank, maximum nullity, and zero forcing number of simple digraphs*. Preliminary report.

Extensive work has been done on problems related to finding the minimum rank among the family of real symmetric matrices whose off-diagonal zero-nonzero pattern is described by a given simple graph G . In this talk, we will discuss the case of simple digraphs, which describe the off-diagonal zero-nonzero pattern of a family of (not necessarily symmetric) matrices. Furthermore, we will establish cut-vertex reduction formulas for minimum rank and zero forcing number for simple digraphs, analyze the effect of deletion of a vertex on minimum rank and zero forcing number, and characterize simple digraphs whose zero forcing number is very low or very high. (Received February 28, 2013)

1090-15-204 **Bryan L Shader*** (bshader@uwyo.edu), Math Department, 1000 E. University Avenue, University of Wyoming, Laramie, WY 82071. *Getting something for nothing (using transversality, linear algebra and combinatorics)*.

Many problems in combinatorial matrix theory reduce to finding a matrix with a certain structure (e.g. with a prescribed zero-nonzero pattern or sign-pattern) having certain properties (e.g. orthogonal rows, prescribed nullity or spectrum). Solving specific problems (e.g. is there a 16×16 symmetric matrix whose graph is the 4-cube having eigenvalues $1, 1, 2, 2, \dots, 7, 7, 8, 8$?) are difficult and akin to looking for a needle in a haystack.

In this talk, we describe how in certain circumstances once one's been fortunate enough to find a needle, one can solve the analogous problem for all "superstructures". The general technique frames the search for the needle as a question about whether or not two surfaces intersect. When the surfaces not only intersect (i.e. a needle is found) but also intersect transversally, then a result that generalizes the inverse function theorem implies that perturbed surfaces corresponding to superstructures intersect (i.e. needles for the super-structures can be found in nearby haystacks).

Verifying transversality for different structures leads to interesting algebraic conditions and problems. Examples of recent successes of using this technique will be given. (Received March 01, 2013)

1090-15-230 **Pablo Tarazaga*** (pablo.tarazaga@tamucc.edu). *On the Structure of the Set of Symmetric Matrices with the Perron-Frobenius Property*.

In this presentation we explore the geometry of the set of symmetric Perron-Frobenius matrices, whose spectral radius is an eigenvalue with a nonnegative associated eigenvectors. We prove that the set, that is not convex, is star convex with the identity matrix as the center. We also describe a few aspects of the geometric structure of the set (Received March 02, 2013)

1090-15-240 **Jason Grout*** (jason.grout@drake.edu), **Steve Butler** (butler@iastate.edu) and **Tracy Hall**. *Bounds on maximum nullity*. Preliminary report.

Let $S(G)$ be the set of real symmetric matrices whose off-diagonal nonzero entries correspond to the edges of a simple graph G . The inertia set of G is the set of all ordered pairs (a, b) such that a matrix in $S(G)$ has a positive eigenvalues and b negative eigenvalues. We describe some more recent advancements in computing bounds on the inertia sets of graphs. (Received March 02, 2013)

1090-15-242 **Wayne W Barrett*** (wayne@math.byu.edu), **Curtis G Nelson, John Sinkovic** and **Tianyi Yang**. *Connections between the minimum rank and inverse eigenvalue problems*. Preliminary report.

Let $S(G)$ be the set of all real symmetric $n \times n$ matrices corresponding to a simple graph G on n vertices. The minimum rank of G is the minimum of the ranks of all matrices in $S(G)$, and the problem of determining it for a given graph G has been intensively studied.

One form of the inverse eigenvalue problem for graphs is the following: Given G , a vertex v of G , and $2n - 1$ real numbers satisfying the interlacing inequalities

$$\lambda_1 \geq \mu_1 \geq \lambda_2 \geq \mu_2 \geq \dots \geq \lambda_{n-1} \geq \mu_{n-1} \geq \lambda_n,$$

determine if there exists a matrix $A \in S(G)$ such that $\lambda_1, \lambda_2, \dots, \lambda_n$ are the eigenvalues of A and μ_1, \dots, μ_{n-1} are the eigenvalues of $A(v)$

Results about minimum rank can be helpful in determining what possible $>$ and \geq signs can occur, particularly in excluding possibilities. There are instances in which a less restrictive set of equalities and inequalities is not attainable, and yet an apparently more restrictive set is attainable. (Received March 02, 2013)

1090-15-267 **Lek-Heng Lim*** (lekheng@galton.uchicago.edu), University of Chicago, Department of Statistics, Chicago, IL 60637, and **Ke Ye** (kye@math.uchicago.edu), University of Chicago, Department of Mathematics, Chicago, IL 60637. *Complexity and Symmetry.*

The p -norm of a matrix can be computed in polynomial time when $p = 1, 2, \infty$, but is NP-hard for all other values of p . The rank of a nonnegative matrix can be computed in polynomial time but its nonnegative rank is NP-hard. Deciding if a symmetric matrix is positive semidefinite can be done in polynomial time but deciding if it is copositive or completely positive are both NP-hard. The determinant of matrix can be computed in polynomial time but the permanent is #P-hard. In this talk we attempt to provide an explanation for such dichotomies from the point of view of invariant theory. We shall argue that in numerical linear algebra, quantities that can be readily computed or properties that can be easily checked are often the ones preserved by a relatively large submonoid of the group that acts naturally on the space of matrices. (Received March 03, 2013)

1090-15-269 **John Sinkovic*** (johnsinkovic@gmail.com), **Wayne Barrett**, **Mark Kempton**, **Nicole Malloy**, **Curtis Nelson** and **William Sexton**. *Decomposing a minimum rank matrix.*

Given a field F and a simple graph G , we denote by $S^F(G)$ the family of F -valued symmetric matrices associated with G through the adjacency of its vertices. For example the adjacency matrix of G is in $S^F(G)$ for any field F and the Laplacian matrix of G is in $S^{\mathbb{Q}}(G)$. The minimum rank of a graph G with respect to a field F is the smallest rank attained by any matrix in $S^F(G)$. Let $\mathcal{MR}^F(G)$ denote the subset of matrices in $S^F(G)$ which achieve the minimum rank of G with respect to F . We discuss recent results showing that for a graph G with low connectivity, matrices in $\mathcal{MR}^F(G)$ can be decomposed or written as a sum of matrices $A_1 + \dots + A_k$ where $A_i \in \mathcal{MR}^F(H_i)$ and each H_i is determined by the graph G . (Received March 03, 2013)

1090-15-332 **Franklin H. J. Kenter*** (fkenter@math.ucsd.edu), 9500 Gilman Drive, UCSD Dept. of Mathematics, MC 0112, La Jolla, CA 92093-0112, and **Michael Tait**. *Hypergraph Coloring with Hyperspectra.*

In spectral graph theory, a well known result by Hoffman says that $\chi(G) \geq 1 - \frac{\lambda_{max}}{\lambda_{min}}$ where χ is the chromatic number and λ_{max} and λ_{min} are the maximum and minimum eigenvalues of the adjacency matrix.

We derive a variant of this inequality for (weak-)hypergraph coloring by considering λ_{max} and λ_{min} to be the extremal values of a multilinear form. Further, we discuss how these techniques lead toward spectral algorithms for hypergraph coloring. (Received March 04, 2013)

1090-15-413 **Alison Gordon Lynch*** (gordon@math.wisc.edu), Department of Mathematics, University of Wisconsin, 480 Lincoln Drive, Madison, WI 53706. *Cauchy Pairs and Cauchy Matrices.*

Let \mathbb{K} denote a field and let V denote a vector space over \mathbb{K} with finite positive dimension. We consider a pair of linear transformations $X : V \rightarrow V$ and $Y : V \rightarrow V$ that satisfies the following three conditions.

- (i) Each of X, Y is diagonalizable.
- (ii) $X - Y$ is rank 1.
- (iii) There does not exist a subspace W of V such that $XW \subseteq W, YW \subseteq W, W \neq 0, W \neq V$.

We call such a pair a Cauchy pair on V . We characterize these pairs and their relationship to Cauchy matrices. Specifically, we show that every Cauchy matrix gives rise to a Cauchy pair and that every Cauchy pair has a canonical transition matrix which is Cauchy. Moreover, we show that this correspondence is bijective up to affine isomorphism. (Received March 05, 2013)

1090-15-424 **H. Tracy Hall*** (h.tracy@gmail.com). *Minimum rank 3 is difficult to determine.* Preliminary report.

The minimum rank of a graph over a field (usually \mathbb{R}) is the smallest rank of a symmetric matrix over the field whose pattern of nonzero off-diagonal entries is given by the edges of the graph. Graphs of minimum rank 1 or 2 are well-characterized, in particular by a finite list of induced-subgraph obstructions. The situation is shown to be completely different for minimum rank 3: No such finite list of obstructions exists, and indeed the problem, while decidable, is equivalent in difficulty to solving an arbitrary system of multi-variable polynomials with integer coefficients. For example, there exists a family of graphs, whose size grows only linearly, such that

no graph in the family can have minimum rank 3 over the rationals precisely because Fermat's Last Theorem is known to hold. It also follows that for any pair of distinct number fields, there exists a graph that has minimum rank 3 over one field but not the other.

The graphs considered are complements of bipartite graphs, in which setting the correspondence can be carried out in both directions: from graphs to systems of equations, and from systems of equations to graphs. (Received March 05, 2013)

16 ► *Associative rings and algebras*

1090-16-18 **Jason Gaddis***, jdgaddis@uwm.edu. *PBW deformations of Artin-Schelter regular algebras.*

In this talk, we explore properties of PBW deformations of Artin-Schelter regular algebras via their homogenizations. We explain how geometric tools of regular algebras can be used to determine simple modules of deformations. A classification in dimension 2 is presented as well as several examples in dimension 3. (Received December 28, 2012)

1090-16-39 **T.Y. Lam** and **Pace P. Nielsen*** (pace@math.byu.edu), Department of Mathematics, Brigham Young University, Provo, UT 84602. *Jacobson Pairs and Regular Elements.*

It is well known that a form of "Jacobson's Lemma" holds for regular elements. That is, the element $\alpha = 1 - ab$ is (von Neumann) regular iff $\beta = 1 - ba$ is also regular. In fact, there is a simple map from the inner inverses of α to those of β . We improve the usual Jacobson map in many different ways, and in the process define the group of inner annihilators. As one application of these ideas, we prove that $1 - ab$ and $1 - ba$ are always equivalent in a unit-regular ring. (Received January 22, 2013)

1090-16-61 **Mohamed F Yousif*** (yousif.1@osu.edu), 4240 Campus Drive, Lima, OH 45804, and **Ismail Amin** and **Yasser F Ibrahim**. *τ -Projective Modules.*

In this talk we introduce the notion of τ -projective modules relative to any preradical τ , where a right R-module M is called τ -N-projective if $\sigma: N \rightarrow K$ is an R-epimorphism with $\tau(N) \rightarrow \ker \sigma$, then every homomorphism $f: M \rightarrow K$ can be lifted to a homomorphism $\lambda: M \rightarrow N$ such that $g\lambda = f$. The module M is called τ -projective (resp., τ -quasi-projective) if M is τ -R-projective (resp., τ -M-projective), and is called strongly τ -projective if it is τ -N-projective for every right R-module N. New and interesting results are obtained when $\tau(M) = \text{rad}(M)$, $\text{soc}(M)$ or $\delta(M)$, where $\text{rad}(M)$, $\text{soc}(M)$ and $\delta(M)$ denotes to the radical, the socle and the δ -submodule of M, respectively. We start our talk by highlighting all the interesting properties of these new notions and show with examples that these notions are non-trivial and natural extensions of projective modules. For example, the class of (strongly) τ -projective right R-modules is closed under isomorphisms, direct sums and summands. The notion of τ -projective cover is introduced and new characterizations of semiperfect and perfect rings in terms of τ -projective covers are provided. (Received February 08, 2013)

1090-16-115 **Adel N Alahmadi**, Adel N. Alahmadi, **S K Jain*** (jain@ohio.edu), 76 Anchor Lane, Springboro, OH 45066, and **Surjeet Singh**. *Almost Self-Injective Rings*. Preliminary report.

The questions (i) whether a local almost right self-injective ring is right self-injective and (ii) whether a right self-injective ring which is also left almost self-injective is two-sided self-injective, had been raised by one of the authors and Beidar, but have remained open. In this talk we will show, more generally, that an almost right self-injective ring without any nontrivial idempotents is indeed right self-injective. We will give an example of a ring which is right self-injective and left almost self-injective but not two-sided self-injective. Further work on semiperfect right almost self-injective rings is in progress (Received February 23, 2013)

1090-16-137 **Allen Herman*** (aherman@math.uregina.ca), Department of Mathematics and Statistics, University of Regina, Regina, SK, Canada. *Schur indices of the rational adjacency algebras of coherent configurations.*

Let (X, S) be a finite coherent configuration. We will examine the structure of the simple components of the semisimple rational adjacency algebra $\mathbb{Q}S$. When (X, S) is a commutative association scheme, the possibilities for these simple components are limited by the cyclotomic eigenvalue conjecture. When (X, S) is noncommutative, the simple components are matrices over division rings. The centers of these division rings are fields of values of irreducible characters. Whether or not the centers of these division rings lie in cyclotomic extensions of \mathbb{Q} is an open question. The dimension of these division algebras is determined by their Schur indices. Algorithms for calculating the Schur indices occurring for finite groups have recently been implemented in GAP and Magma,

but the main ingredients for these algorithms are not available for coherent configurations. Nevertheless, there are several situations where the calculation of a Schur index for a coherent configuration can be reduced to the calculation of a Schur index for a finite group, and we will survey some of these situations. (Received February 26, 2013)

1090-16-155 **Ivo Herzog*** (herzog.23@osu.edu), 4240 Campus Drive, Lima, OH 45804, and **Sonia L’Innocente**, Camerino, Italy. *Diophantine Sets of Representations.*

Let $L = \mathfrak{sl}(2, k)$ be the Lie algebra of traceless 2×2 matrices with entries in a field k of characteristic 0. The universal enveloping algebra $U(L)$ acts on the affine k -plane $k[x, y]$ of polynomials in two commuting variables with coefficients in k . Considered as a $U(L)$ -module, the affine k -plane decomposes as a direct sum $k[x, y] = \bigoplus_n L(n)$ of simple representations $L(n)$, indexed by \mathbb{N} , given by the homogeneous polynomials of total degree n .

Every object F of the free abelian category $\text{Ab}(U(L))$ over the universal enveloping algebra may be thought of as a functor on the category of finitely generated $U(L)$ -modules. We will use the Matijasevic-Robinson-Davis-Putnam Theorem to prove that the support of F in \mathbb{N} , given by $\{n \in \mathbb{N} \mid F(L(n)) \neq 0\}$, is a Diophantine set of natural numbers. (Received February 27, 2013)

1090-16-191 **Jae Keol Park** (jkp1128@yahoo.com), Department of Mathematics, Pusan National University, Busan, 609-735, South Korea, and **Syed Tariq Rizvi*** (rizvi.1@osu.edu), Department of Mathematics, The Ohio State University, Lima, OH 45804. *On Baer Module Hulls.* Preliminary report.

A ring R is called Baer (right Rickart) if the right annihilator of any subset (single element) of R is a (right) direct summand of R . This was extended to a general module theoretic setting: Let R be any ring, M be an R -module and $S = \text{End}_R(M)$. M is said to be a Baer module if the right annihilator in M of any subset of S is a direct summand of M . The module M is called a Rickart module if for all $\varphi \in S$, $\text{Ker} \varphi$ is a direct summand of M . Several research articles have been published on these notions and it has been shown that there are close links between Baer and extending properties of rings and modules. Closely related notions of quasi-Baer, FI-extending and p.q.-Baer modules have also been studied extensively in ring and module theoretic settings.

For a ring R , its quasi-Baer, extending and FI-extending ring hulls (i.e. essential overrings of R which happen to be the smallest or minimal such) were introduced and studied recently. However, almost nothing is known about the existence or description of a Baer module hull or a Rickart module hull of a given module M_R . We will present some explicit examples of Baer module hulls and show instances where a Baer module hull may or may not exist. (Received February 28, 2013)

1090-16-209 **Xuan Yu***, 203 Avery Hall, Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588. *Chern character for matrix factorization via Chern-Weil.*

We use the Atiyah class for a matrix factorization to give a Chern-Weil type construction for its Chern character; this allows us to realize the Chern character in an explicit way. It also generalizes the existing result to any smooth k -algebra Q with k a commutative ring that contains \mathbb{Q} and any $f \in Q$. Our result agrees with the very recent one obtained by Platt. We also study some basic properties of the Chern character. (Received March 01, 2013)

1090-16-211 **Sergio R López-Permouth*** (lopez@ohio.edu), 321 Morton Hall, Department of Mathematics, Ohio University, Athens, OH 45701. *When Algebras have bases consisting entirely of units.* Preliminary report.

For an arbitrary ring R , we call an R -algebra A an invertible R -algebra if it has an R -basis consisting entirely of units in A . We will start by presenting various ideas on the subject developed in an ongoing collaboration with Jeremy Moore and Steve Szabo. We will then conclude the talk by giving a progress report on the problem of determining the directed graphs E for which the Leavitt path algebra $L_K(E)$ over a field K is an invertible K -algebra, a joint project with Nick Pilewski. We give examples that are invertible and examples that are not; we will also present some sufficient conditions for an Leavitt Path Algebra not to be invertible. However, locating precisely the borderline between the two cases remains an elusive problem. (Received March 01, 2013)

1090-16-212 **Cynthia Farthing*** (cynthia-farthing@uiowa.edu), Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52242, and **Lisa Orloff Clark, Aidan Sims and Mark Tomforde.** *A Groupoid Generalization of Leavitt Path Algebras.*

Let G be a locally compact, Hausdorff groupoid in which s is a local homeomorphism and the unit space is totally disconnected. If c is a continuous cocycle from G to a discrete group Γ , then we show that the set $A(G)$ of locally-constant, compactly supported functions on G is a dense $*$ -subalgebra of $C_c(G)$. This algebra is universal for algebraic representations of the collection of compact open bisections of G , and it generalizes the

Leavitt path algebras and Kumjian-Pask algebras associated to row-finite graphs and higher-rank graphs. We also prove versions of the Cuntz-Krieger and graded uniqueness theorems for $A(G)$. (Received March 01, 2013)

1090-16-215 **Andrew Conner***, Department of Mathematics, Wake Forest University, Winston Salem, NC 27109, and **Ellen Kirkman** and **W. Frank Moore**. *Periodic free resolutions from noncommutative matrix factorizations*. Preliminary report.

A matrix factorization of an element x in a commutative ring A is an ordered pair of maps of free A -modules $(\varphi : F \rightarrow G, \psi : G \rightarrow F)$ such that $\varphi\psi = xI_G$ and $\psi\varphi = xI_F$. Eisenbud showed matrix factorizations are intimately related to periodic minimal free resolutions over complete intersections. For example, there is a bijective correspondence between equivalence classes of reduced matrix factorizations of x over A and isomorphism classes of nontrivial periodic minimal free resolutions (of maximal Cohen-Macaulay modules) over $A/(x)$.

In this preliminary report, we discuss progress toward a theory of noncommutative matrix factorizations. Specifically, we define a *twisted* matrix factorization of an element x in a noncommutative ring A , prove twisted matrix factorizations give rise to periodic free resolutions, and give examples of rings over which twisted matrix factorizations exist in relative abundance. (Received March 01, 2013)

1090-16-224 **Zak Mesyan*** (zmesyan@uccs.edu), Department of Mathematics, University of Colorado, Colorado Springs, CO 80918. *Generalizations of Shoda's Theorem*.

A celebrated theorem of Shoda from 1936 states that over any field K (of characteristic 0), every matrix with trace 0 can be expressed as a commutator $AB-BA$. I will describe various attempts to generalize this result over the years. (Received March 01, 2013)

1090-16-253 **Frauke M. Bleher***, Department of Mathematics, University of Iowa, 14 MLH, Iowa City, IA 52242, and **Ted Chinburg** and **Birge Huisgen-Zimmermann**. *Closures of orbits of dimension 2*. Preliminary report.

Let k be an algebraically closed field, let Λ be a finite dimensional k -algebra, let P be a projective indecomposable Λ -module, and let C be a submodule of $\text{rad}(P)$. We concentrate on the case in which the orbit of $\text{Aut}_\Lambda(P)$ acting on C in the appropriate Grassmannian is an affine plane \mathbb{A}_k^2 . Our goal is to bound the geometry of the orbit closure of such a C , using “good blow ups” of relatively minimal smooth projective surfaces, such that the bounds only depend on k and $\dim_k(C)$. (Received March 03, 2013)

1090-16-260 **Gangyong Lee*** (lee.2375@osu.edu), Department of Mathematics, The Ohio State University, Columbus, OH 43210, **Cosmin S. Roman** (cosmin@math.ohio-state.edu), Department of Mathematics, The Ohio State University, Lima, OH 45804, and **Xiaoxiang Zhang** (z990303@seu.edu.cn), Department of Mathematics, Southeast University, Nanjing 211189, Peoples Rep of China. *On a generalization of primitive rings*.

Jacobson, in 1945, introduced the notion of primitive rings and proved the structure theorem for primitive rings as an analogue of the Wedderburn-Artin structure theorem for semisimple artinian rings. The study of the class of primitive rings has been a topic of wide interest.

Now, we introduce the notion of a rudimentary ring as a generalization of a primitive ring. A ring R is called right rudimentary if there exists a faithful right R -module M such that $\text{End}_R(M)$ is a division ring. We provide results on this new concept and give a number of examples that delimit our results and the notions. We extend some well-known results related to the endomorphism ring of a module over a commutative ring. (Received March 03, 2013)

1090-16-290 **Alexander J Diesl*** (adiesl@wellesley.edu), Wellesley College, 106 Central Street, Wellesley, MA 02481, and **Thomas J Dorsey**. *Quasipolar and Pseudopolar Matrix Rings*.

Following recent work of Z. Wang and J. Chen, an element r of a ring R is called *pseudopolar* if there is an idempotent e such that $r - e$ is invertible, $e \in \text{comm}^2(r)$ and $r^k e \in \text{rad}(R)$ for some k (note that this definition differs from, but is equivalent to, that given by Wang and Chen). The study of pseudopolar elements draws inspiration from a number of sources, including the theories of strongly clean rings and Drazin inverses. In this talk, we will explore conditions under which matrices over suitable rings are pseudopolar. (Received March 04, 2013)

1090-16-326 **Allen D. Bell*** (adbell@uwm.edu), Dept. of Mathematical Sciences, University of Wisconsin-Milwaukee, PO Box 413, Milwaukee, WI 53201-0413. *Associated primes of induced modules over semigroup-graded rings.*

Suppose T is a G -graded ring, where G is a unique product semigroup with identity e , and let $R = T_e$ be the identity component of T . We describe the associated prime ideals of the induced T -module $M \otimes_R T$ in terms of annihilators of submodules of the R -module M when the grading is strong or when T is a skew semigroup ring.

The case $G = \mathbb{N}$ corresponds to study of the skew polynomial ring $R[x; \sigma]$. In this case, we show that the associated primes are prime ideals of the form IT where I is the largest σ -invariant ideal contained in the annihilator of a T -prime submodule of M , or of a twisted T -prime submodule if σ is not an automorphism. We relate T -primeness to previous definitions of σ -primeness. (Received March 04, 2013)

1090-16-364 **Andrew Conner** (connerab@wfu.edu), **Ellen Kirkman** (kirkman@wfu.edu), **James Kuzmanovich** (kuz@wfu.edu) and **W. Frank Moore*** (moorewf@wfu.edu). *Cohomology of Monomial Algebras.*

Let A be a connected graded noncommutative monomial algebra over a field k . We associate to A a finite graph $\Gamma(A)$ called the CPS graph of A . Finiteness properties of the Yoneda algebra $\text{Ext}_A(k, k)$ including Noetherianity, finite Gelfand-Kirillov dimension, and finite generation are characterized in terms of $\Gamma(A)$. We show that these properties, most notably finite generation, can be checked by means of a terminating algorithm. (Received March 04, 2013)

1090-16-409 **Frederick Goodman*** (frederick-goodman@uiowa.edu), Department of Mathematics MLH, University of Iowa, Iowa City, IA 52242. *Cellular bases in towers of cellular algebras.*

I will give a brief introduction to cellularity and discuss a construction of cellular bases in towers $(A_n)_{n \geq 1}$ of cellular algebras satisfying a coherence condition. Typical examples are the tower of Hecke algebras of type A, or Brauer or BMW algebras. This is based on a paper with John Enyang. (Received March 05, 2013)

1090-16-425 **Alexander J. Diesl** and **Thomas J. Dorsey*** (dorsey@ccrwest.org), 4320 Westerra Ct., San Diego, CA 92126. *Recent progress on clean and strongly clean rings.*

An element of a ring is said to be clean if it is the sum of a unit and an idempotent; strongly clean if it is the sum of a unit and an idempotent that commute. We'll discuss recent progress on clean and strongly clean rings, as well as variants thereof. (Received March 05, 2013)

17 ► Nonassociative rings and algebras

1090-17-116 **Jens Köpflinger*** (jens@prisage.com), 105 E Avondale Dr, Greensboro, NC 27403. *Beyond complex number exponentiation: Two prototype algebras.*

Two algebra prototypes are shown in the context of generalized complex number exponentiation: "W Space" [1] and "PQ Space" [2]. By suitably restating defining relations of the complexes, each prototype is defined as the resulting primitive system when modifying one of these relations. The terminology choice "generalized exponentiation" is motivated from the geometric locus of b^t in the two dimensional vector space over the reals, where b is a generalized imaginary base and t a real number. Fractal structures emerge from repeatedly squaring a number, building an exponential function as its conventional Taylor polynomial, and using the Mandelbrot set algorithm. We advertise for interest in exploring what general mathematical context these systems may exist in, and hint at applicability for some generalized exponentiation in fundamental physical law.

References:

[1] J. A. Shuster, J. Köpflinger, Elliptic complex numbers with dual multiplication, Appl. Math. Comput. 216 (2010), pp. 3497-3514 (www.jenskoepflinger.com/P/PaperShusterKoepl.WSpace.pdf).

[2] J. A. Shuster, J. Köpflinger, Doubly nilpotent numbers in the 2D plane, Appl. Math. Comput. 217 (2011), pp. 7295-7310 (www.jenskoepflinger.com/P/PaperShusterKoepl-PQSpace.pdf). (Received February 23, 2013)

1090-17-298 **Andrew T Wells*** (awells@ecok.edu), 1100 E 14th Street PMB E-4, Ada, OK 74820. *Zorn vector matrices over $\mathbb{Z}/p^k\mathbb{Z}$. Preliminary report.*

Paige used the vector matrix construction over fields to produce simple Moufang loops. It has already been shown that this construction generalizes to the class of commutative rings, although the resulting loops are not simple. In this talk, the Moufang loops created from Zorn vector matrices over $\mathbb{Z}/p^k\mathbb{Z}$ are examined, extending previous work done over $\mathbb{Z}/4\mathbb{Z}$. (Received March 04, 2013)

1090-17-360 **Garrett Johnson*** (johnsongw@cua.edu) and **Christopher Nowlin**. *FRT-Bialgebras and Quantum Schubert Cells*.

The aim of this talk is to draw connections between quantum Schubert cell algebras and FRT-bialgebras. The universal bialgebra construction of Faddeev, Reshetikhin, and Takhtajan is an approach to obtaining the quantized coordinate ring of an algebraic group. I will describe how quantizations of nilradicals of cominuscle parabolics of simple finite dimensional Lie algebras, and quotients thereof, map isomorphically onto distinguished subalgebras of FRT-bialgebras. (Received March 04, 2013)

1090-17-400 **Tevian Dray*** (teviaan@math.oregonstate.edu), Department of Mathematics, Oregon State University, Corvallis, OR 97331, **John Huerta** (john.huerta@gmail.com), Centro de Análise Matemática, Geometria e Sistemas Dinâmicos, Instituto Superior Técnico, 1049-001 Lisboa, Portugal, **Joshua Kincaid** (kincajos@math.oregonstate.edu), Department of Mathematics, Oregon State University, Corvallis, OR 97331, **Corinne A. Manogue** (corinne@physics.oregonstate.edu), Department of Physics, Oregon State University, Corvallis, OR 97331, **Aaron Wangberg** (awangberg@winona.edu), Department of Mathematics and Statistics, Winonra State University, Winona, MN 55987, and **Robert A. Wilson** (r.a.wilson@qmul.ac.uk), School of Mathematical Sciences, Queen Mary, University of London, London, E1 4NS, United Kingdom. *Magic squares of Lie groups*.

The Tits-Freudenthal magic square yields a description of certain real forms of the exceptional Lie algebras in terms of a pair of (possibly split) division algebras. At the group level, the first two rows are well understood, including a geometric understanding of the minimal representations of F_4 and E_6 in terms of the Albert algebra. In the third row, the minimal representation of E_7 consists of Freudenthal triples.

We present here several results at the group level: A complete description of the corresponding “ 2×2 ” magic square as $SU(2, \mathbb{K}' \otimes \mathbb{K})$, the use of Cartan decompositions involving all 5 real forms of E_6 to identify chains of real subgroups of the particular real form $SL(3, \mathbb{O})$, and a new description of Freudenthal triples in terms of “cubies”, the components of an antisymmetric rank-3 representation of (generalized) symplectic groups, thus providing a unified, geometric interpretation of Freudenthal triples as a single object, and a new description of the minimal representation of E_7 .

In future work, we hope to extend this construction to the fourth row, ultimately providing a unified description of the full magic square. (Received March 05, 2013)

18 ► Category theory; homological algebra

1090-18-9 **Pye Phyong Aung*** (pye.aung@ndsu.edu). *Amalgamated Duplication, Pseudo-canonical Covers, and Gorenstein Homological Algebra*. Preliminary report.

When C is a semidualizing module over a commutative ring, Holm and Jørgensen studied some connections between C-Gorenstein injectivity/projectivity and Nagata’s trivial extension. We generalized some of those results to other general constructions, including the amalgamated duplication of a ring along an ideal introduced by D’anna and Fontana. We also identified some key properties of those general constructions that enable their connections to Gorenstein injectivity and projectivity. (Received December 03, 2012)

20 ► Group theory and generalizations

1090-20-32 **J.D. Phillips*** (jophilli@nmu.edu), 1401 Presque Ilse Avenue, Marquette, MI 49855. *The structure of conjugacy closed loops*.

We detail the structure of conjugacy closed loops, with special emphasis on power associative conjugacy closed loops. This is joint work with Michael Kinyon. (Received January 18, 2013)

1090-20-34 **Anthony B. Evans*** (anthony.evans@wright.edu), Dept. of Math. and Stat., Wright State University, Dayton, OH 45435. *The existence problem for strong complete mappings*. Preliminary report.

For a finite group G , a bijection $\theta: G \rightarrow G$ is a *complete mapping* of G if the mapping $x \mapsto x\theta(x)$ is a bijection, an *orthomorphism* of G if the mapping $x \mapsto x^{-1}\theta(x)$ is a bijection, and a *strong complete mapping* of G if it is both a complete mapping and an orthomorphism of G . While the existence problem for complete mappings has been solved, the existence problem for strong complete mappings remains open.

We will discuss progress toward the resolution of the existence problem for strong complete mappings and suggest possible directions for further research. (Received January 18, 2013)

1090-20-58 **Mouna R. Aboras*** (mmrm9804@yahoo.com), Department of Mathematics, University of Denver, 2360 S Gaylord St, Denver, CO 80208. *Dihedral-like constructions of automorphic loops*. Preliminary report.

Automorphic loops are loops in which all inner mappings are automorphisms. We study a generalization of the dihedral construction for groups. Namely, if $(G, +)$ is an abelian group, $m \geq 1$ and $\alpha \in \text{Aut}(G)$, let $\text{Dih}(m, G, \alpha)$ on $\mathbb{Z}_m \times G$ be defined by

$$(i, u)(j, v) = (i + j, ((-1)^j u + v)\alpha^{ij}).$$

The resulting loop is automorphic if and only if $m = 2$ or $(\alpha^2 = 1$ and m is even). The case $m = 2$ was introduced by Kinyon, Kunen, Phillips, and Vojtěchovský. We present several structural results about the automorphic dihedral loops in both cases. (Received February 07, 2013)

1090-20-65 **Paul-Hermann Zieschang*** (zieschang@utb.edu), Brownsville, TX 78520. *Non-commutative association schemes of rank 6*.

The classification of non-commutative association schemes of finite order and of rank 6 is a major project in scheme theory that has been started in [2]. In [2], it was shown that normal closed subsets of these schemes must have cardinality 2 or 3. While no example of a non-commutative scheme of finite order and of rank 6 with a normal closed subset of cardinality 2 is known, such schemes with a normal closed subset of cardinality 3 are easy to construct. In fact, there are examples of non-commutative schemes of finite order and of rank 6 which have a symmetric normal closed subset of cardinality 3 and there are examples of such schemes which have a non-symmetric normal closed subset of cardinality 3. In my lecture, I will discuss the first of these two cases; cf. [1].

[1] French, C. and Zieschang, P.-H.: On the normal structure of non-commutative association schemes of rank 6, preprint.

[2] Hanaki, A. and Zieschang, P.-H.: On imprimitive non-commutative association schemes of order 6, to appear in *Comm. Algebra* (Received February 11, 2013)

1090-20-147 **Harvey I Blau*** (blau@math.niu.edu), Department of Mathematical Sciences, Northern Illinois University, DeKalb, IL 60115, and **Gang Chen**, School of Mathematics and Statistics, Central China Normal University, Wuhan, 430079, Peoples Rep of China. *Table Bases as Unions of Proper Closed Subsets*.

Suppose that the distinguished basis B of a table algebra is a union of n proper closed subsets (whose intersection we denote as C). Our main result is that if all the positive structure constants of the standard quotient (double coset) basis $B//C$ are at least 1, then the order (valency) $o(B//C)$ is bounded above by a function of n . This generalizes a result of B. H. Neumann for finite groups, and is applied to character rings of finite groups and to association schemes. (Received February 26, 2013)

1090-20-153 **Jonathan D.H. Smith*** (jdhsmith@iastate.edu), Department of Mathematics, 396 Carver Hall, Iowa State University, Ames, IA 50011. *Digroups and diquasigroups*. Preliminary report.

Motivated by questions from non-commutative geometry, Loday split a semigroup multiplication into two dimonoid multiplications, with dialgebras as a linear analogue. The corresponding analogues of Lie algebras are Leibniz algebras, but integration of Leibniz algebras is an open problem, with digroups as the currently best partial solution.

In order to shed new light on this question, a general procedure for breaking up the operations of an algebra is established. Given a constant-free type, a directional type is obtained by pointing to each of the arguments of the original, undirected type. Loday's dimonoids and digroups are shown to arise, using the general procedure, from suitably axiomatized semigroups and groups respectively. For quasigroups, various choices of equational bases lead to various varieties of directional quasigroups. Under one natural axiomatization, the variety of quasigroups is shown to be directionally complete, in the sense that the corresponding directional variety is again the variety of quasigroups. Another axiomatization yields $(4 + 2)$ -quasigroups. Digroups are then shown to be equivalent to a certain class of $(4 + 2)$ -quasigroups. (Received February 27, 2013)

1090-20-188 **Mark B. Greer*** (mark.greer@du.edu), University of Denver - Mathematics, John Greene Hall, Room 203, 2360 S. Gaylord St, Denver, CO 80208. *A class of loops categorically isomorphic to Bruck loops of odd order*.

Given a uniquely 2-divisible group, we give a construction (originally used by Baer) for creating a new class of loops we call Γ -loops. After showing that Γ -loops are power-associative, our main goal is showing a categorical isomorphism between Bruck loops of odd order and Γ -loops of odd order. Once this has been established, we

can use the well known structure of Bruck loops of odd order to derive the Lagrange, Cauchy, Odd Order, Sylow and Hall theorems for Γ -loops of odd order, as well as the nilpotence of finite Γ - p -loops (p odd). In particular, this answers an open problem regarding the existence of Sylow p -subloops and Hall π -subloops in commutative automorphic loops. (Received February 28, 2013)

1090-20-197 **Alper Bulut*** (alper.bulut@wmich.edu), Kalamazoo, MI 49008. *K-Loops from G , G a subgroup of $GL(H)$ for H a separable Hilbert space.* Preliminary report.

There has been a growing interest on K -loops for the last two decades. H.Kiechle has studied K -loops and provided many examples of K -loops which has been constructed from G , G a subgroup of $GL(n, K)$, $K = \mathbb{R}(i)$ where \mathbb{R} is n -Real. I will survey the finite dimensional case from the Lie theoretic point of view and extend this construction to subgroups of $GL(H)$ where H is infinite dimensional separable Hilbert space over complexes, and discuss new results and possible new directions in this area. (Received March 01, 2013)

1090-20-200 **Angela L. Antonou*** (angela@math.niu.edu), Department of Mathematical Sciences, Northern Illinois University, DeKalb, IL 60115. *A characterization of commutative standard table algebras with at most one nontrivial multiplicity.* Preliminary report.

We study commutative standard table algebras with at most one nontrivial multiplicity. All multiplicities are trivial if and only if the table algebra is an abelian group algebra. The main result shows that there exists exactly one nontrivial multiplicity if and only if the table basis is the wreath product of a two-dimensional subalgebra and an abelian group. The theorem applies to adjacency algebras of commutative association schemes with exactly one primitive idempotent matrix of rank greater than one. A theorem of Seitz that characterizes finite groups with exactly one irreducible representation of degree greater than one is another corollary of the main theorem. (Received March 01, 2013)

1090-20-213 **Christopher P French*** (frenchc@grinnell.edu). *Functors from Association Schemes.*

By imposing a more restrictive definition on morphisms of association schemes, we construct a category of association schemes in such a way that a number of classical constructions, like taking thin radicals or adjacency algebras, become functorial. This allows us to show that the representations of an association scheme determine a module over the representation ring of the group obtained by factoring out the thin residue. (Received March 01, 2013)

1090-20-219 **Jonathan I Hall*** (jhall@math.msu.edu), Michigan State University, Department of Mathematics, 619 Red Cedar Road, East Lansing, MI 48824. *Special Majorana algebras and 3-transposition groups.* Preliminary report.

Ivanov has introduced Majorana algebras as generalizations of the Griess algebra for the monster. These algebras are generated by idempotents whose adjoint action has, canonically, four distinct eigenspaces. The Majorana algebra is special if one of these eigenspaces is trivial. Miyamoto and Shpectorov have noted that the special algebras admit large 3-transposition groups of automorphisms. We discuss these groups and some of the related algebras. (Received March 01, 2013)

1090-20-243 **David Stanovský**, Charles University in Prague, and **Petr Vojtěchovský*** (petr@math.du.edu), University of Denver, Denver, CO 80208. *A case for new associators.*

The traditional associators defined by $(xy)z = x(yz)[x, y, z]$ do not behave well. For instance, the subloop generated by all associators is not necessarily normal. More natural and useful definitions of associators are obtained from the Freese-McKenzie commutator theory for congruence modular varieties. (Received March 02, 2013)

1090-20-263 **David C Meyer***, University of Iowa. *Do universal deformation rings recognize fusion?*

ABSTRACT. Let Γ be a finite group, and V be an absolutely irreducible $\mathbb{F}_p\Gamma$ -module. By Mazur, V has a universal deformation ring $R(\Gamma, V)$ whose structure is closely related to the cohomology groups $H^i(\Gamma, \text{Hom}_{\mathbb{F}_p}(V, V))$ for $i = 1, 2$. In this talk, we consider the case when Γ is an extension of an abelian or dihedral group G with order relatively prime to p , by an elementary abelian p -group N . We compute $H^i(\Gamma, \text{Hom}_{\mathbb{F}_p}(V, V))$ for $i = 1, 2$ and $R(\Gamma, V)$, and then discuss the extent to which $R(\Gamma, V)$ can see the fusion of N in Γ . (Received March 03, 2013)

1090-20-312 **Andrew P. Wang*** (andrewwang42@gmail.com), Department of Mathematical Sciences, Northern Illinois University, DeKalb, IL 60115. *Coxeter Table Algebras*. Preliminary report. Coxeter table algebras are a generalization of Coxeter schemes as studied by Zieschang. We examine the structure of Coxeter table algebras, in particular their connection with Bourbaki and Couillens' generic algebras associated with Coxeter groups. (Received March 04, 2013)

1090-20-317 **Caroline Kettlestrings*** (csjacobs24@yahoo.com) and **Harvey I Blau**. *Classification of Standard Commutative Nilpotent Table Algebras of Order p^3* . Preliminary report. We algebraically classify (up to exact isomorphism) the standard, nilpotent, commutative table algebras of order p^3 . We also consider which of these arise from association schemes. (Received March 04, 2013)

1090-20-362 **Nicholas Teff*** (nicholas-teff@uiowa.edu), University of Iowa, 14 MacLean Hall, Department of Mathematics, Iowa City, IA 52240. *A Divided Difference Operator for the Hessenberg Representation*.

The Hessenberg representation is a family of representations of the symmetric group. A flow-up basis allows us to obtain the irreducible decomposition of the representation. In this talk a divided difference operator is defined which constructs a flow-up basis in a new special case. This generalizes the classical divided difference operator defined on the coinvariant algebra defined by M. Demazure and Bernstein-Gelfand-Gelfand. Our methods rely heavily on the root systems and Bruhat order of the symmetric group. (Received March 04, 2013)

1090-20-371 **Andrew Rajah*** (andy@cs.usm.my), School of Mathematical Sciences, Universiti Sains Malaysia, 11800 USM, Penang, Malaysia. *Construction of minimally nonassociative Moufang loops of odd order*.

A Moufang loop is defined as minimally nonassociative if each of its proper subloop is associative. One can always construct a nonassociative Moufang loop whose order is a multiple of any of these loops. O.Chein has constructed and given methods for constructing nonassociative Moufang loops (including those that are minimally nonassociative). We give examples of known minimally nonassociative Moufang loops and demonstrate methods used for constructing new ones of odd order. (Received March 04, 2013)

1090-20-380 **Michael Kinyon*** (mkinyon@du.edu), University of Denver, Denver, CO 80208, and **Rick M. Thomas** (rmt@mcs.le.ac.uk), Department of Computer Science, Leicester, LE1 7RH, United Kingdom. *Loops presented by finite automata*.

In studying infinite algebraic structures, it is natural to ask which are computable, a question that only makes sense relative to some computational paradigm. The seminal paper of Khoussainov and Nerode introduced what are now called *FA-presentable structures* whose relations can be checked by finite automata. Of course, the general idea of using finite automata to check structures is not new, as the success of the theory of automatic groups shows. A motivation for the study of general FA-presentability is that the first-order theory of any FA-presentable structure is decidable.

The study of FA-presentable algebraic structures is now an active research programme among mathematicians and computer scientists. The strongest result in this direction is the Oliver-Thomas Theorem: A finitely generated group is FA-presentable if and only if it is virtually abelian.

In this talk, I will discuss FA-presentable quasigroups and loops. For instance, let Q be a loop with a finitely generated, normal, abelian, associative subloop A contained in the nucleus such that Q/A is finite. Then Q is FA-presentable. So, for example, every finitely generated commutative Moufang loop is FA-presentable. I will conclude by listing some open problems. (Received March 05, 2013)

1090-20-387 **Kenneth W Johnson*** (kwj1@psu.edu). *A collection of algebras arising from a loop or a quasigroup*. Preliminary report.

The character theory of a loop or quasigroup Q is calculated from the orbits of the action of Q on itself by left and right multiplication. The information in the characters is equivalent to that in the commutative algebra generated by the (element sums) of the corresponding orbits. This is a direct generalisation of the result for a group G , and originated from the "group determinant". In the case of a group, for each $k = 1, 2, \dots$ " k -characters" which are functions on G^k , have produced interesting results. For each k there is a " k -class algebra" which for $k = 1$ is the usual class algebra. A recent discovery has been that $k > 1$ the information in the k -class algebra is not the same as that in the k -characters.

Concretely, for $k = 2$ the 2-class algebra of a group G is the algebra generated by the element sums of the orbits of the inner automorphisms and the map $(a, b) \rightarrow (b, a)$ acting on $G \times G$. It is not necessarily commutative.

Corresponding algebras for loops and quasigroups exist. They need not be associative or commutative.

The talk will discuss some of their properties. (Received March 05, 2013)

1090-20-399 **Benjamin A Phillips*** (baphil@umd.umich.edu), MI. *A family of even ordered simple loops.*

We shall discuss a hybrid construction for building certain kinds of commutative, even ordered loops from odd ordered groups. In particular, we'll focus on an interesting family of loops arising from odd ordered cyclic groups. We'll show that the subloop structure of the constructed loops can be easily understood, and use this information to prove the loops are simple. (Received March 05, 2013)

1090-20-410 **Clifton E. Ealy Jr.*** (clifton.e.ealy@wmich.edu), Department of Mathematics, Western Michigan University, Kalamazoo, MI 49008-4152. *On Computable loops: computable Paige loops and computable loops given by transversals in F_n , the free group on n generators.* Preliminary report.

In this talk, we will consider computable loops following M. Rabin's, Computable Algebra, General Theory and Theory of Computable Fields. We extend the idea of computable to the reals and p -adics following Marian Boykan Pour-El and Jonathan Ian Richards, Computability in Analysis and Physics. This allows us to examine the computable Paige loops over the reals and p -adics. Then we examine loops given by transversals in F_n , these loops are computable. (Received March 05, 2013)

1090-20-426 **Jenya Kirshtein***, ykirshte@du.edu. *One-sided inner mapping groups and multiplication groups of Cayley-Dickson loops.*

The Cayley–Dickson loop Q_n is the multiplicative closure of basic elements of the algebra constructed by n applications of the Cayley–Dickson doubling process (the first few examples of such algebras are real numbers, complex numbers, quaternions, octonions, sedenions). We establish the structure of the inner mapping groups and the multiplication groups of Q_n . We show that the one-sided inner mapping groups are equal and the one-sided multiplication groups are isomorphic. (Received March 05, 2013)

28 ► Measure and integration

1090-28-2 **Marianne Csornyei**, University of Chicago, Department of Mathematics, Chicago, IL. *Differentiability of Lipschitz functions and tangents of sets.*

We will show how elementary product decompositions of measures can detect directionality in sets, and show how this can be used to describe non-differentiability sets of Lipschitz functions on \mathbb{R}^n , and to understand the phenomena that occur because of behaviour of Lipschitz functions around the points of null sets.

In order to prove this we will need to prove results about the geometry of set of small Lebesgue measure: we show that sets of small measure are always contained in a “small” collection of Lipschitz surfaces.

The talk is based on a joint work with G. Alberti, P. Jones and D. Preiss. (Received March 18, 2012)

1090-28-145 **Naomi Kochi*** (nkoch1@unmc.edu) and **Dora Matache**. *Sensitivity Analysis of Biological Boolean Networks Using Nonadditive Set Function Information Fusion.*

A Boolean model of signal transduction in a generic fibroblast cell is used to investigate the sensitivity of the network to molecule perturbations. There are several network/node attributes such as connectivity and types of Boolean functions that are responsible for the dynamics observed in any Boolean networks. However, each of these individual attributes can be affected by any of the others, alone or in combination. Thus a true understanding of how these attributes combine to produce dynamical effects can only come from studying them in an integrated fashion. We use an algebraic method for information fusion based on the Choquet integral with respect to nonadditive set functions to assess the joint contribution of Boolean network attributes to the degree of sensitivity of the network to individual node mutations. (Received February 26, 2013)

30 ► Functions of a complex variable

1090-30-47 **Mark David Comerford*** (mcomerford@math.uri.edu), Lippitt Hall, Room 200, Kingston, RI 02881. *Meridians and the Carathéodory Topology.*

In what sense can one say that two plane domains of the same connectivity are similar? Such questions are of particular relevance in complex dynamics where one uses quasiconformal surgery to ‘glue’ dynamical systems together. Carathéodory in 1952 formulated a notion of convergence for pointed domains which goes some way towards answering this question. However, there are problems as the conformal invariants and even the connectivity of a convergent sequence of pointed domains may not be preserved in the limit. We show how extra conditions may be imposed so as to formulate a notion of boundedness so that a limit of pointed domains of the

same connectivity will have again have this connectivity (provided none of the complementary components of any of the domains is a point). This notion of boundedness can be formulated quantitatively in terms of certain special hyperbolic geodesics known as *meridians* of the domain. There are also other of equivalent formulations in terms purely geometric conditions, Riemann mappings to slit domains, and boundedness in a suitable moduli space. (Received January 28, 2013)

1090-30-119 **Oleg Muzician*** (omuzician@bmc.cuny.edu), Brooklyn, NY 11214, and **Jun Hu**.
Generalization of Conformally Natural Extension.

Conformally natural and continuous extensions were originally introduced by Douady and Earle for circle homeomorphisms, and later by Abikoff, Earle and Mitra for continuous degree-1 monotone circle maps. In this work, we construct conformally natural and continuous extensions for all continuous circle maps. We also provide a criterion for such extensions to be surjective and an example of a continuous surjective circle map with a nonsurjective extension (Received February 24, 2013)

1090-30-194 **Erina Kinjo*** (kinjo.e.aa@m.titech.ac.jp), Oh-okayama 2-12-1, Meguro-ku, 152-8852, Tokyo, Japan. *On Teichmüller metric and the length spectra of topologically infinite Riemann surfaces.*

We consider the length spectrum metric d_L in infinite dimensional Teichmüller space $T(R_0)$. It is known that d_L defines the same topology as that of the Teichmüller metric d_T on $T(R_0)$ if R_0 is a topologically finite Riemann surface. In 2003, H. Shiga proved that d_L and d_T define the same topology on $T(R_0)$ if R_0 is a topologically infinite Riemann surface which can be decomposed into pairs of pants such that the lengths of all their boundary components except punctures are uniformly bounded by some positive constants from above and below.

In this talk, we extend Shiga's result to Teichmüller spaces of Riemann surfaces satisfying a certain geometric condition. We also give a sufficient condition for these metrics to have different topologies on $T(R_0)$, which is a generalization of a result given by Liu-Sun-Wei. (Received March 01, 2013)

1090-30-232 **Jinhua Fan*** (jinhuaфан@hotmail.com), Department of Applied Mathematics, Nanjing University of Science and Technology, Nanjing, 210094, Peoples Rep of China, and **Jun Hu** (junhu@brooklyn.cuny.edu), Department of Mathematics, Brooklyn College of CUNY, Brooklyn, NY NY 11210. *Induced earthquake measure map on asymptotic Teichmüller space.*

Let \mathbb{D} be the open unit disk in the complex plane \mathbb{C} and centered at the origin, and let $\mathcal{ML}_b(\mathbb{D})$ be the collection of Thurston bounded measured geodesic laminations on \mathbb{D} . We introduce an equivalent relation on $\mathcal{ML}_b(\mathbb{D})$ such that the earthquake measure map induces a bijection between the asymptotic Teichmüller space $AT(\mathbb{D})$ and the quotient space $\mathcal{AML}_b(\mathbb{D})$ of $\mathcal{ML}_b(\mathbb{D})$ under the equivalent relation. Furthermore, we introduce a topology on $\mathcal{AML}_b(\mathbb{D})$ under which the bijection is a homeomorphism between $AT(\mathbb{D})$ and $\mathcal{AML}_b(\mathbb{D})$ with respect to the Teichmüller metric on $AT(\mathbb{D})$. Corresponding results are also developed for a bijection and then a homeomorphism between the tangent space $\mathcal{AZ}(\mathbb{S}^1)$ of $AT(\mathbb{D})$ at a base point and $\mathcal{AML}_b(\mathbb{D})$ with respect to the asymptotic cross-ratio norm on $\mathcal{AZ}(\mathbb{S}^1)$ and the topology on $\mathcal{AML}_b(\mathbb{D})$. (Received March 04, 2013)

1090-30-283 **Ara S. Basmajian*** (abasmajian@gc.cuny.edu). *Lengths of closed geodesics.*

We investigate the relationship between lengths of closed geodesics and intersection number in various contexts on a hyperbolic surface. Two particular consequences of our work are

- 1) A closed geodesic of length less than $\frac{1}{2} \log \frac{k}{2}$, has at most k self-intersections.
- 2) For each natural number k , let M_k be the infimum of lengths of closed geodesics having k self-intersections.

Then M_k is realized by some geodesic. (Received March 04, 2013)

1090-30-318 **Yunping Jiang, Sudeb Mitra, Hiroshige Shiga and Zhe Wang***
(wangzhecuny@gmail.com), 4265 Kissena BLVD, APT. 127, Flushing, NY 11355.
Quasiconformal Motion.

I will talk about cross ratio and quasiconformal motion. A counter example of a Sullivan and Thurston's result about quasiconformal motion will be constructed. The extension theorem of quasiconformal motion and Earle-Gardienr-Lakic's equivalence theorem of cross ratio norm and Teichmüller norm will also be discussed in this talk. This is a joint work with Yunping Jiang, Sudeb Mitra, Hiroshige Shiga. (Received March 04, 2013)

1090-30-412 **Christopher J. Bishop**, Department of Mathematics, Stony Brook University, Stony Brook, NY 11794-3651, and **Hrant Hakobyan*** (hakobyan@math.ksu.edu), 138 Cardwell Hall, Department of Mathematics, Manhattan, KS 66506-2602. *Expansion and compression principles in quasiconformal mapping theory.*

We study the distortion of Hausdorff dimension of families of Ahlfors regular sets under a quasymmetric map f between metric spaces. We show the following two principles:

- Fiberwise expansion for product spaces implies global expansion
- A QC map of a Euclidean space cannot increase the dimension of “most” Ahlfors d -regular sets.

We also estimate the number/size of exceptional sets whose images have dimension $\geq d' > d$. The precise statements of these results involve modulus estimates for families of measures. For planar quasiconformal maps, the general estimates imply that if $E \subset \mathbb{R}^2$ is d -regular, then some component of $f(E \times \mathbb{R})$ has dimension $\leq 2/(d+1)$, and we construct examples to show this bound is sharp. In addition, we construct 1-dimensional sets E so that $f(E \times \mathbb{R})$ contains no rectifiable sub-arc. These results generalize work of Balogh, Monti and Tyson and answer several open questions in quasiconformal distortion theory. (Received March 05, 2013)

31 ► Potential theory

1090-31-258 **Erik Lundberg*** (elundber@math.purdue.edu), **Dmitry Khavinson** and **Razvan Teodorescu**. *A free boundary problem in potential theory.*

An “exceptional domain” is an unbounded domain that admits a “roof function”, a positive harmonic function with zero Dirichlet data and constant Neumann data. In physical terms, viewing the roof function as a potential, the free boundary is simultaneously a set of constant potential and constant magnitude of force. I will discuss progress on a problem posed by L. Hauswirth, F. Helein, and F. Pacard to characterize exceptional domains in the plane. I will also explain interpretations of exceptional domains within disparate settings: null quadrature domains, fluid dynamics, quadratic differentials, and minimal surfaces. (Received March 03, 2013)

33 ► Special functions

1090-33-93 **Jae-Ho Lee*** (jhlee@math.wisc.edu), 480 Lincoln Dr, Madison, WI 53706. *Q-polynomial distance-regular graphs and the double affine Hecke algebra of rank one.*

Let Γ denote a Q -polynomial distance-regular graph with vertex set X . We assume that Γ has q -Racah type and contains a Delsarte clique C . Fix a vertex $x \in C$. We partition X according to the path-length distance to both x and X . This is an equitable partition. For each cell in this partition, consider the corresponding characteristic vector. These characteristic vectors form a basis for a \mathbb{C} -vector space W .

The universal double affine Hecke algebra of type (C_1^\vee, C_1) is the \mathbb{C} -algebra \hat{H}_q defined by generators $\{t_n^\pm\}_{n=0}^3$ and relations (i) $t_n t_n^{-1} = t_n^{-1} t_n = 1$; (ii) $t_n + t_n^{-1}$ is central; (iii) $t_0 t_1 t_2 t_3 = q^{-1/2}$. In this talk, we display an \hat{H}_q -module structure for W . (Received February 20, 2013)

35 ► Partial differential equations

1090-35-6 **Kazuo Yamazaki*** (kyamazaki@math.okstate.edu), Department of Mathematics, Oklahoma State University, 401 Mathematical Sciences, Stillwater, OK 74078. *Regularity criteria of N-dimensional porous media equation in terms of one partial derivative or pressure scalar field.*

We obtain new regularity criteria and smallness condition for the global regularity of the N -dimensional supercritical porous media equation. In particular, it is shown that in order to obtain global regularity result, one only needs to bound a partial derivative in one direction or the pressure scalar field. Our smallness condition is also in terms of one direction, dropping conditions on $(N-1)$ other directions completely, or the pressure scalar field. The proof relies on key observations concerning the incompressibility of the velocity vector field and the special identity derived from Darcy’s law. (Received February 18, 2013)

1090-35-16 **Qi Han*** (kylinhhan@math.uh.edu), PGH 686, Math Dept., Univ. of Houston, 4800 Calhoun Road, Houston, TX 77004, and **Giles Auchmuty** (auchmuty@uh.edu), PGH 696, Math Dept., Univ. of Houston, 4800 Calhoun Road, Houston, TX 77004. *Finite energy function spaces on exterior regions.*

The finite energy space $E^{1,p}(U)$ is introduced on an exterior region U in R^N with a compact, Lipschitz boundary, when $N \geq 3$ and $p \geq 1$.

Functions in $E^{1,p}(U)$ are required to decay at infinity in a measure-theoretic sense and be L^p -integrable of their weak gradients, with mild locally integrable conditions assumed. This definition resembles that of Lieb and Loss's Analysis, section 8, where it was given on R^N .

When $p > N$, $E^{1,p}(U)$, as the usual Sobolev space $W^{1,p}(U)$, is a subspace of the space of all locally Hölder continuous functions on \bar{U} .

When $1 < p < N$, one has $W^{1,p}(U) \subsetneq E^{1,p}(U)$, and it is a real Banach space under the gradient L^p -norm. Also, we denote $E^1(U)$ when $p = 2$, which is a real Hilbert space with respect to the gradient L^2 -inner product.

The harmonic Dirichlet-Poisson and Neumann and Robin problems are well-posed in $E^1(U)$, as existence and uniqueness can be given. Also, using a theory of exterior harmonic Steklov eigen-problems, spectral representations of solutions of these harmonic boundary value problems are given, and the exterior Poisson's kernel is described. Moreover, a reproducing kernel for the subspace of all exterior finite energy harmonic functions in $E^1(U)$ is given. (Received December 21, 2012)

1090-35-36 **Suncica Canic*** (canic@math.uh.edu), 4800 Calhoun Rd., Houston, TX 77204, and **Boris Muha**. *A nonlinear moving-boundary parabolic-hyperbolic problem arising in blood flow modeling: a constructive existence proof.*

Motivated by fluid-structure interaction problems arising in blood flow, we consider a nonlinear, unsteady, moving-boundary problem of parabolic-hyperbolic type modeling the interaction between blood flow and elastic/viscoelastic arterial walls. The fluid flow, which is driven by the time-dependent pressure data, is governed by 2D incompressible Navier-Stokes equations, while the elastodynamics of the cylindrical wall is modeled by the 1D cylindrical Koiter shell model. Two cases are considered: the linearly viscoelastic and the linearly elastic Koiter shell. The fluid and structure are fully coupled (2-way coupling) via the kinematic and dynamic lateral boundary conditions.

In this talk we will show the main steps in the proof of the existence of weak solutions to the two FSI problems (the viscoelastic and the elastic case). The main novelty is in the method of proof, which is based on a new semi-discrete, operator splitting numerical scheme, known as the kinematically coupled scheme. The backbone of the kinematically coupled scheme is the well-known Marchuk-Yanenko scheme, also known as the Lie splitting scheme. We effectively prove convergence of that numerical scheme to a solution of the corresponding nonlinear FSI problem. (Received January 20, 2013)

1090-35-37 **Ciprian G Gal*** (cgal@fiu.edu), Florida International University, Building DM 435 B, Miami, FL 33199. *On degenerate parabolic equations with dynamic boundary conditions.*

We wish to present some recent developments concerning the solvability of some classes of quasilinear parabolic equations with dynamic boundary conditions. We will describe issues from well-posedness to the long time asymptotic behavior as time goes to infinity. We show how to derive new conditions which reflect an exact balance between the internal and the boundary mechanisms involved, even when both the nonlinear sources contribute in opposite directions. Blow up of some solutions will also be touched on. (Received January 20, 2013)

1090-35-38 **Joseph L. Shomberg*** (jshomber@providence.edu), Providence College, Department of Mathematics & Computer Science, 212 Howley Hall, Providence, RI 02918, and **Ciprian G. Gal**. *Attractors of the Hyperbolic Relaxation of Reaction Diffusion Equations with Dynamic Boundary Conditions.*

Under consideration is the hyperbolic relaxation of the semilinear reaction-diffusion equation,

$$\varepsilon u_{tt} + u_t - \Delta u + f(u) = 0,$$

$\varepsilon \in [0, 1]$, with the prescribed dynamic boundary condition,

$$\partial_{\mathbf{n}} u + u + u_t = 0.$$

For all singular and nonsingular values of the perturbation parameter, we obtain global attractors with optimal regularity. After fitting both problems into a common framework, a proof of the upper-semicontinuity of the family of global attractors is given. The result is motivated by the seminal work of J. Hale and G. Raugel in *Upper semicontinuity of the attractor for a singularly perturbed hyperbolic equation*, J. Differential Equations

73 (1988). We also show that for all values of the perturbation parameter, the corresponding solution operator admits an exponential attractor. (Received January 21, 2013)

1090-35-50 **Paul Sacks** and **Mahamadi Warma*** (mjwarma@gmail.com), Department of Mathematics, University of Puerto Rico, Rio Piedras Campus, San Juan, PR 00936-8377. *Semi-linear elliptic and elliptic-parabolic equations with Wentzell boundary conditions and L^1 -data.*

Let $\Omega \subset \mathbb{R}^N$ be a bounded smooth domain with boundary $\partial\Omega$ and let α and β be maximal monotone graphs in \mathbb{R}^2 with $0 \in \alpha(0) \cap \beta(0)$. In the first part, given $f \in L^1(\Omega), g \in L^1(\partial\Omega)$, we characterize the existence of weak solutions to the semi-linear elliptic equation $-\Delta u + \alpha(u) \ni f$ in Ω with the boundary conditions $-\Delta_\Gamma u + \partial_\nu u + \beta(u) \ni g$ on $\partial\Omega$. In the second part, we show that the elliptic-parabolic problem

$$\begin{cases} v_t - \Delta u = h_1, & v \in \alpha(u) \text{ in } (0, T) \times \Omega, \\ w_t - \Delta_\Gamma u + \partial_\nu u = h_2, & w \in \beta(u) \text{ on } (0, T) \times \partial\Omega, \\ v(0) = v_0 \text{ in } \Omega, w(0) = w_0 \text{ in } \partial\Omega \end{cases} \quad (1)$$

is associated with an abstract Cauchy problem in $L^1(\Omega) \times L^1(\partial\Omega)$ which has a unique mild solution (v, w) for every given v_0, w_0, h_1 and h_2 satisfying a certain compatibility condition. (Received February 01, 2013)

1090-35-70 **Ivan Blank** and **Zheng Hao*** (haozheng@math.ksu.edu), Mathematics Department, 138 Cardwell Hall, Manhattan, KS 66506-2602. *The Mean Value Theorem for Divergence Form Elliptic Operators.*

In 1963, Littman, Stampacchia, and Weinberger proved a mean value theorem for elliptic operators in divergence form with bounded measurable coefficients. In the Fermi lectures in 1998, Caffarelli stated a much simpler mean value theorem for the same situation, but did not include the details of the proof. We show all of the nontrivial details needed to prove the formula stated by Caffarelli. (Received February 15, 2013)

1090-35-71 **Ivan Blank*** (blanki@math.ksu.edu), Mathematics Department, 138 Cardwell Hall, Manhattan, KS 66506-2602, and **Zheng Hao** (haozheng@math.ksu.edu), Mathematics Department, 138 Cardwell Hall, Manhattan, KS 66506-2602. *The Obstacle Problem for Divergence Form Elliptic Operators.* Preliminary report.

We develop the theory for the obstacle problem for elliptic operators in divergence form. We will describe existence, uniqueness, nondegeneracy, and a quadratic bound for the solutions. We may begin describing some of the development of the regularity theory for the free boundary. (Received February 15, 2013)

1090-35-86 **Lizheng Tao*** (ltao@math.okstate.edu), 401 MSCS O.S.U., stillwater, 74078, and **Durga K.C., Dipendra Regmi** and **Jiahong Wu.** *Slightly super-critical dissipative operators related to 2D Boussinesq equations.*

This talk will focus on the global regularity problem concerning some generalized versions of the Boussinesq system. The problems are raised from a group of dissipative operators which are in the slightly super-critical regime. A generalized Besov is introduced as a result of these operators. We will talk about the necessary inequalities related to such operators that will be used in the proof of global regularity of the whole system. (Received February 19, 2013)

1090-35-92 **Milena Stanislavova*** (stanis@math.ku.edu), Department of Mathematics, University of Kansas, Lawrence, KS 66045. *Linear stability of subsonic waves for the one-dimensional Benney-Luke equation.*

We develop a general theory to treat the linear stability of certain special solutions of second order in time evolutionary PDEs. As an application we study the stability of traveling wave solutions for the subsonic waves in the Benney-Luke equation. The result is a complete characterization of the stability and instability regions in terms of a threshold wave speed. (Received February 20, 2013)

1090-35-96 **Daomin CAO*** (dmcao@amt.ac.cn), 55 Zhong Guan Cun Dong Lu, Haidian District, Beijing, 100190, Peoples Rep of China. *Regularization of steady point vortices for the ideal fluids.*

In this talk, the speaker will talk about the regularization of steady vortices solution ideal incompressible fluids of two dimension. The equation describing the fluids is Euler equation. It turns out that the so called Kirchoff-Routh function plays an important role in the existence of the steady vortices solutions. Indeed, any critical point can deduce a steady point vortex solution. In this talk, the speaker will show how to construct approximate (smooth) solutions to the singular steady point vortices solution if the points are non-degenerate critical points of Kirchoff-Routh function. (Received February 20, 2013)

1090-35-100 **Phuc Cong Nguyen*** (pcnguyen@math.lsu.edu), Louisiana State University, 303 Lockett Hall, Baton Rouge, LA 70803. *Global Muckenhoupt-Wheeden type bounds on Reifenberg flat domains, with applications to quasilinear Riccati type equations.*

We present a nonlinear Calderón-Zygmund theory and weighted norm inequalities of Muckenhoupt-Wheeden type for a class of quasilinear equations with measure data. Our results are obtained globally over exterior uniformly thick domains or domains that are sufficiently flat in the sense of Reifenberg. These global bounds lead to a resolution of an existence problem for quasilinear Riccati type equations with a gradient source term of arbitrary power law growth. (Received February 21, 2013)

1090-35-123 **Andrei Tarfulea*** (tarfulea@math.princeton.edu), Department of Mathematics, Princeton University, Fine Hall, Washington Road, Princeton, NJ 08544-1000. *Vanishing of Long-Time Average Viscosity for SQG Equations.* Preliminary report.

We examine the inviscid limit of long-time averages of the damped and driven surface quasigeostrophic equation on the torus. Making use of stationary statistical solutions, we prove that the rate of dissipation of energy vanishes. We also show how stationary statistical solutions satisfy an energy balance and converge to a renormalized stationary statistical solution for the inviscid equation. (Received February 24, 2013)

1090-35-140 **Gerhard O Strohmer*** (gerhard-strohmer@math.uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52242. *About the existence and stability of solutions close to equilibria for gas balls under the influence of gravity.*

We consider configurations of n gas balls ($n=1, 2, \dots$) moving in equilibrium under the influence of gravity and discuss the existence and stability of solutions for all time that begin close to these equilibria. These gas balls consist of barotropic viscous compressible fluids assumed to be chemically and physically homogeneous and bounded by a free boundary moving with the flow without surface tension. We study the question of existence of such equilibrium states, and, in case the equilibria are energy stable, prove that they are also linearly stable as solutions of the dynamic equations (Received February 26, 2013)

1090-35-146 **Alejandro Velez-Santiago*** (alejandro.velez2@upr.edu), University of Puerto Rico at Humacao, Tejas Avenue, Street 908, Humacao, PR 00791. *Solvability of linear local and nonlocal Robin problems over $C(\bar{\Omega})$.*

Let $\Omega \subseteq \mathbb{R}^N$ be a bounded Lipschitz domain. We first consider an elliptic (non-symmetric) boundary value problem with general Robin boundary conditions. The boundary conditions can be either local or nonlocal, depending on the conditions imposed on the elliptic operator. We prove that this boundary value problem is uniquely solvable, and moreover we show that such weak solution is Hölder continuous on $\bar{\Omega}$. We also obtain that a realization of the associated differential operator with generalized local or nonlocal Robin boundary conditions generates an analytic C_0 -semigroup of angle $\pi/2$ over $C(\bar{\Omega})$. We conclude by applying the elliptic regularity theory to solve the corresponding Cauchy problem over $C(\bar{\Omega})$. (Received February 26, 2013)

1090-35-167 **Zhuangyi Liu*** (zliu@d.umn.edu). *Stability and Regularity of an Abstract System of Coupled Hyperbolic and Parabolic System.*

In this talk, for parameters $(\alpha, \beta) \in S = [0, 1] \times [0, 1]$, we consider an abstract system of coupled hyperbolic and parabolic equations

$$\begin{cases} u_{tt} = -Au + \gamma A^\alpha \theta, \\ \theta_t = -\gamma A^\alpha u_t - k A^\beta \theta, \\ u(0) = u_0, \quad u_t(0) = v_0, \quad \theta(0) = \theta_0 \end{cases} \quad (1)$$

where A is a self-adjoint, positive definite operator on a Hilbert space H .

We will give a complete stability analysis and regularity analysis for (1). Indeed, the unit square S can be divided into stability sub-regions where (1) is exponentially stable, polynomially stable, and unstable, respectively. On the other hand, the unit square S can also be divided into regularity sub-regions where the semigroup (1) is analytic, of Gevrey class, and non-smooth, respectively.

(Received February 27, 2013)

1090-35-178 **Yanqiu Guo*** (yanqiu.guo@weizmann.ac.il), Faculty of Mathematics and Computer Science, The Weizmann Institute of Science, 76100 Rehovot, Israel, and **Edriss S. Titi**. *PERSISTENCY OF ANALYTICITY FOR QUASI-LINEAR WAVE EQUATIONS: AN ENERGY-LIKE APPROACH.*

I will briefly introduce the theory of Gevrey classes, and employ it to study the persistence of analyticity of solutions to quasi-linear wave equations with real analytic nonlinearity. Specifically, it is proven that the solution remains spatial analytic, with respect to some of its spatial variables, during its whole life-span, provided the

initial data is analytic with respect to these spatial variables. In addition, we find a lower bound for the radius of the spatial analyticity of the solution that might shrink either algebraically or exponentially, in time, depending on the structure of the nonlinearity. (Received February 28, 2013)

1090-35-184 **Pierre-Emmanuel Jabin***, pjabin@umd.edu. *Hydrodynamic limit of granular gases to pressureless Euler in dimension 1*. Preliminary report.

We investigate the limit of models for granular gases when the dissipation of kinetic energy becomes very high. This corresponds for example to situations with a very high frequency of collisions for particles with a non vanishing viscosity; but it can also occur when the restitution coefficient of the energy for each collision becomes very small. In those scalings, one would expect two particles to have near identical velocities after a collision; thus leading to the sticky particles dynamics of pressureless Euler. However the limit system is extremely singular and ruling out possible oscillations in the limiting process was a long open problem. We introduce a new functional which is compatible with the dissipative nature of granular gases and forces the density in phase space to be monokinetic at the limit. (Received February 28, 2013)

1090-35-208 **Lorena Bociu*** (lvbociu@ncsu.edu), **Petronela Radu** and **Daniel Toundykov**. *Regular Solutions for Wave Equations with Supercritical Sources and Exponential-to-Logarithmic Damping*.

Supercritical sources (i.e. $p > 5$ in 3D) have been a major challenge in the investigation of finite energy ($H^1 \times L^2$) solutions to wave equations for many years. While the damping term is usually considered in the context of stability of solutions (as in classical control theory), in the case of strong nonlinearities present in the system, the damping plays a critical role in establishing existence of solutions. Even local existence of finite energy solutions in 3D requires the relation $p \leq \frac{6m}{m+1}$ between the exponents p of the source and m of the damping. However, we show that smoother initial data ($H^2 \times H^1$) yields regular solutions with no correlation between the source and the damping. We prove local existence of solutions for any $p \geq 1$ (in 3D and 4D) and any monotone damping, including exponential, logarithmic, or none at all. This results extend the previous theory which focuses on damping of polynomial growth and only allows for critical sources (i.e. $p < 5$ in 3D). (Received March 01, 2013)

1090-35-220 **Tilmann Glimm*** (glimmt@wwu.edu), Department of Mathematics, Bellingham, WA 98229. *Reflector Design and Optimal Mass Transport*.

Optical reflector design is concerned with the problem of transforming a given input beam into an output beam with desired intensity distribution. This is to be achieved with a system of reflecting surfaces. For instance, one may want to transform a beam of parallel rays into another beam of parallel rays with a different intensity distribution, or a spherical wavefront generated by a point source into a beam of parallel rays. Energy preservation generally leads to fully nonlinear equations of Monge-Ampère-type. We will present how several such reflector design problems can be reformulated as certain mass transportation problems between domains in \mathbb{R}^2 and/or the unit sphere S^2 . This method leads to existence and uniqueness results for a large class of input and output data and to numerical methods based on linear optimization. (Received March 01, 2013)

1090-35-227 **George Avalos*** (gavalos@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588. *A Frequency Domain Approach for obtaining Polynomial Decay for Certain Coupled PDE Models*.

In this talk, we shall demonstrate how delicate frequency domain relations and estimates, associated with coupled systems of partial differential equation models (PDE's), may be exploited so as to establish results of uniform and rational decay. In particular, our focus will be upon decay properties of coupled PDE systems of different characteristics; e.g., hyperbolic versus parabolic characteristics. For such PDE systems of contrasting dynamics, the attainment of explicit decay rates is known to be a difficult problem, inasmuch as there has not been an established methodology to handle hyperbolic-parabolic systems. As one particular example, we shall work to conclude uniform decays for structural acoustic dynamics. In these PDE models, the structural component is subjected to a structural damping ranging from viscous (weak) to strong (Kelvin-Voight). The rational decay rates we derive for this problem explicitly reflect the extent of the damping which is in play. Since the damped elastic component of the coupled dynamics is present on only a portion of the boundary, there will necessarily be assumptions imposed upon the geometry. (Received March 02, 2013)

1090-35-236 **Mohammad Rammaha*** (mrammaha1@unl.edu), Department of Mathematics, University of Nebraska- Lincoln, Lincoln, NE 68588-0130, and **Hiroyuki Takamura, Hiroshi Uesaka** and **Kyouhei Wakasa**. *Blow-Up of Positive Solutions to Wave Equations in High Space Dimensions*. Preliminary report.

In this talk, we consider the Cauchy problem for the semilinear wave equation:

$$u_{tt} - \Delta u = F(u) \quad \text{in } \mathbb{R}^n \times [0, \infty),$$

where the space dimension $n \geq 2$, $F(u) = |u|^p$, or $F(u) = |u|^{p-1}u$ with $p > 1$, and with Cauchy data are non-zero and non-compactly supported. A brief history on this problem and Cauchy problem with compactly supported data will be presented. In addition, a sketch of the proof a blow up result for positive radial solutions will be discussed. Our results generalize and extend the results of Takamura (1995) and Takamura, Uesaka and Wakasa (2010). The main technical difficulty in this work lies in obtaining the lower bounds for the free solution when both initial position and initial velocity are non-identically zero. (Received March 02, 2013)

1090-35-239 **Lihe Wang*** (lwang.iowa@gmail.com), Department of Mathematics, The University of Iowa, Iowa City, IA 52246. *Liouville Theorems for positive solutions in a cylinder for uniformly elliptic operators*.

We will prove Liouville type theorems for Dirichlet problem of general uniformly elliptic equations in either divergent or nondivergent form on domains of infinite cylinders. (Received March 02, 2013)

1090-35-241 **Yuri Latushkin** (latushkin@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211, and **Alim Sukhtayev*** (alim@math.tamu.edu), 620B Blocker, Department of Mathematics, Mailstop 3368, Texas A&M University, College Station, TX 77843-3368. *The Evans function and the Weyl-Titchmarsh function*.

We describe relations between the Evans function, a modern tool in the study of stability of traveling waves and other patterns for PDEs, and the classical Weyl-Titchmarsh function for singular Sturm-Liouville differential expressions and for matrix Hamiltonian systems. Also, for the scalar Schrödinger equation, we discuss a related issue of approximating eigenvalue problems on the whole line by that on finite segments. (Received March 02, 2013)

1090-35-270 **Sukjung Hwang*** (s.hwang@ed.ac.uk), School of Mathematics, U of Edinburgh, James Clerk Maxwell Building, The King's Buildings, Mayfield Road, Edinburgh, EH9 3JZ, United Kingdom, and **Martin Dindos**. *The Dirichlet boundary value problems for second order parabolic operators satisfying a Carleson condition*.

We consider boundary value problems for second order parabolic operator $Lu = u_t - \text{div}(A\nabla u)$ in a noncylindrical domain $\Omega = \{(x_0, x, t) \in \mathbb{R} \times \mathbb{R}^{n-1} \times \mathbb{R} \mid x_0 > \psi(x, t)\}$. We establish L^2 solvability of the Dirichlet problems when the coefficients of the operator L with a certain Carleson condition with small norm. (Received March 03, 2013)

1090-35-274 **Eva Hang Koo*** (hang-koo@uiowa.edu) and **Stephen Gustafson**. *Global Well-posedness for 2D Radial Schrödinger Maps into the Sphere*.

The Schrödinger map from \mathbf{R}^n into \mathbf{S}^2 arises as a continuum model of a ferromagnet. It can also be viewed as a generalization of the free Schrödinger equation where the flat target space is replaced by a Kähler manifold. In this talk, we will present a recent global well-posedness result for the Schrödinger map from \mathbf{R}^2 to \mathbf{S}^2 for radially-symmetric initial data, without any smallness assumption. This is done by transforming the equation into a cubic, non-local Schrödinger equation and exploiting the framework of Kenig-Merle and Killip-Tao-Visan-Zhang. (Received March 03, 2013)

1090-35-278 **Matthias Eller** and **Daniel Toundykov*** (dtoundykov@unl.edu), NE. *Carleman estimates and stabilization of hyperbolic systems in absence of geometric observability conditions*.

The sharp sufficient conditions for observability in control problems can be formulated via geometric optics and are linked to the structure of closed geodesics in the underlying physical domain. However, the necessary unique continuation property for PDEs is an intrinsically weaker requirement and does not impose such restrictions. It is, therefore, sometimes possible to stabilize an evolution system by placing feedback controls on subsets of the domain that fail to satisfy the geometric conditions. The price to pay is the necessity to work with smoother solutions and the stabilization rates obtained thereby are no longer exponential.

In this work we present specialized Carleman estimates and a generalization of a pioneering strategy due to G. Lebeau and L. Robbiano to prove uniform stability (for strong solutions) of 1st-order hyperbolic systems without reliance on the geometric observability assumptions. (Received March 04, 2013)

1090-35-286 **Yongki Lee*** (yklee@iastate.edu), 245 Sinclair Ave, unit 319, Ames, IA 50014, and **Hailiang Liu**. *A class of nonlocal conservation laws: local wellposedness and sub-thresholds for finite time shock formation.*

We investigate a class of nonlocal conservation laws with the nonlinear advection coupling both local and nonlocal mechanism, which arises in several applications such as the collective motion of cells and traffic flows. It is prove that the C^1 solution regularity of this class of conservation laws will persist at least for a short time. This persistency may continue as long as the solution gradient remains bounded. Based on this result, we further identify sub-thresholds for finite time shock formation in traffic flow models with some looking ahead relaxation. (Received March 04, 2013)

1090-35-287 **Chunquan Tang*** (ctang@iastate.edu), Department of Mathematics, Iowa State University, Ames, IA 50011, and **Gary M. Lieberman**. *Mixed boundary value problems for quasilinear elliptic equations.* Preliminary report.

Regularity of classical solutions for elliptic equations with Dirichlet boundary condition or oblique boundary condition has been studied for a long time. It has been shown that assuming other data are smooth enough, the regularity improves as the regularity of the boundary of the domain improves.

However, if on part of the boundary, a Dirichlet condition is prescribed and on the other part, an oblique condition is prescribed, the regularity of the solutions depends also on the angle of the domain at the place where two parts of boundary meet. This relation has been studied for linear elliptic equations.

This talk is concerned with quasilinear elliptic equations with mixed boundary conditions. Under angle conditions and other conditions, existence theorems are shown through various a priori estimates. The results include prescribed mean curvature equations with mixed boundary conditions as one of examples. (Received March 04, 2013)

1090-35-289 **Matthias Eller***, Department of Mathematics, Washington, DC 20057. *A general approach to the boundary controllability of hyperbolic systems.*

We extend the method of Walter Littman developed for the boundary controllability of strictly hyperbolic equations to a large class of hyperbolic systems at least in the case of constant coefficients. Our approach is based on results due to Atiyah, Bott, and Gårding concerning the singularities of the fundamental solution of hyperbolic operators. (Received March 04, 2013)

1090-35-321 **Maksym Pryporov*** (pryporov@iastate.edu), 301 South 4th 9, Ames, IA 50010, and **Hailiang Liu**. *Error Estimates of the Bloch Band-Based Gaussian Beam Superposition for the Schrödinger Equation.*

This work is concerned with asymptotic approximations of the semi-classical Schrödinger equation in periodic media using Gaussian beams. For the underlying equation, subject to a highly oscillatory initial data, a hybrid of the Gaussian beam approximation and homogenization leads to the Bloch eigenvalue problem and associated evolution equations for Gaussian beam components in each Bloch band. We formulate a superposition of Bloch-band based Gaussian beams to generate high frequency approximate solutions to the original wave field. For initial data of a sum of finite number of band eigen-functions, we prove that the first-order Gaussian beam superposition converges to the original wave field at a rate of $\epsilon^{1/2}$, with ϵ the semiclassically scaled constant, as long as the initial data for Gaussian beam components in each band are prepared with same order of error or smaller. For a natural choice of initial approximation, a rate of $\epsilon^{1/2}$ of initial error is verified. (Received March 04, 2013)

1090-35-327 **Hailiang Liu** (hliu@iastate.edu), Caver Hall 434, Iowa State University, Ames, IA 50011, and **Hui Yu*** (legendyu@iastate.edu), Carver Hall 438, Iowa State University, Ames, IA 50011. *The entropy satisfying discontinuous Galerkin methods for Fokker-Planck equations.*

Computation of Fokker-Planck equations with satisfying long time behavior is important in many applications and difficult in resolving solution structures induced by nonstandard forces. Entropy satisfying conservative methods are proven to be powerful to ensure both equilibrium preserving and mass conservation properties at the discrete level. Following [H. Liu and H. Yu, SIAM Journal on Numerical Analysis 2012, 50(3), 1207-1239], we present entropy satisfying discontinuous Galerkin methods to solve the Fokker-Planck equation of the finitely extensible nonlinear elastic dumbbell model for polymers, subject to homogeneous fluids. Both semidiscrete and fully discrete methods satisfy two desired properties: mass conservation and entropy satisfying in the sense that these schemes are shown to satisfy discrete entropy inequalities for the quadratic entropy. These ensure that the schemes are entropy satisfying and preserve the equilibrium solutions. Then we will discuss the extension to higher order approximations in the framework of DDG (Direct Discontinuous Galerkin), with the

above properties. We will also introduce discontinuous Galerkin schemes preserving the positivity of probability density functions to Fokker-Planck equations. (Received March 04, 2013)

1090-35-330 **Thomas J Clark*** (s-tclark15@math.unl.edu) and **George Avalos**. *Wellposedness and Stability of a PDE Model Arising in a 3D Fluid-Structure Interaction.*

We will present qualitative results on a partial differential equation (PDE) model of certain fluid-structure dynamics. Wellposedness of this model is established by means of establishing a nonstandard semigroup generator representation of the operator; this representation is ultimately enabled by an appropriate elimination of the pressure. The coupled PDE model involves the Stokes system which evolves on a three dimensional domain \mathcal{O} being coupled to a fourth order plate equation, with rotational inertia parameter γ , which evolves on a flat portion Ω of the boundary of \mathcal{O} . The coupling is implemented via the Dirichlet trace of the Stokes system fluid variable - so the no-slip condition is necessarily not in play - and via the boundary trace of the pressure, which essentially acts as a forcing term on the elastic portion of the boundary. We note here that inasmuch as the Stokes fluid velocity does not vanish on $\partial\mathcal{O}$, the pressure variable cannot be eliminated by the classic Leray Projector. (Received March 04, 2013)

1090-35-356 **Hailiang Liu*** (hliu@iastate.edu), Iowa State University, Carver 434, Ames, IA 50011. *GAUSSIAN BEAM METHODS FOR THE HELMHOLTZ EQUATION.*

The Helmholtz equation is widely used to model wave propagation problems in application areas like electromagnetics, geophysics and acoustics. Numerical simulation of Helmholtz becomes expensive when the frequency of the waves is high. In this talk I shall present the recent construction of the Gaussian beam approximations to solutions of the high frequency Helmholtz equation with a localized source, and show how to estimate the error in these approximations. This is a joint work with J. Ralston, O. Runborg and N. Tanushev (Received March 04, 2013)

1090-35-365 **Hyung Ju Hwang** and **Juhi Jang*** (juhijang@math.ucr.edu), Department of Mathematics, University of California, Riverside, Riverside, CA 92521, and **Juan J. L. Velazquez**. *Fokker-Planck equation with absorbing boundary condition.*

We study the initial-boundary value problem for the Fokker-Planck equation in an interval with absorbing boundary conditions. We develop a theory of well-posedness of classical solutions for the problem and also show that the resulting solutions decay exponentially for long times. (Received March 04, 2013)

1090-35-372 **Tong Li*** (tong-li@uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52246. *Global Dynamics of Chemotaxis Models.*

We investigate local and global existence, blowup criterion and long time behavior of classical solutions for a hyperbolic-parabolic system derived from the Keller-Segel model describing chemotaxis. (Received March 04, 2013)

1090-35-391 **Ronghua Pan*** (panrh@math.gatech.edu), 686 Cherry Street, Atlanta, GA 30332, and **Weizhe Zhang**, 686 Cherry Street, Atlanta, GA 30332. *Compressible Navier-Stokes equations with temperature dependent dissipation.*

From its physical origin, the viscosity and heat conductivity in compressible fluids depend on absolute temperature through power laws. The mathematical theory on the well-posedness and regularity on this setting is widely open. I will report some recent progress made on this direction, with emphasis on the lower bound of temperature, and global existence of solutions in one or multiple dimensions. The relation between thermodynamics laws and Navier-Stokes equations will also be discussed. This talk is based on joint works with Weizhe Zhang. (Received March 05, 2013)

1090-35-392 **Changhui Tan*** (jefftan@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *Critical thresholds on compressible Eulerian dynamics with nonlocal alignment.*

Self-organized behavior is very common in nature and human societies. One widely discussed example is the flock formed by birds flying towards the same direction. Several models such as Cucker-Smale and Motsch-Tadmor are very successful in characterizing the flocking behavior. In this talk, we focus on the hydrodynamics of these flocking models, concerning whether the macroscopic system preserves the flocking properties. This system can be also viewed as compressible Eulerian dynamics with nonlocal alignment. We show a critical threshold phenomenon for the hydrodynamics system. Under suitable initial conditions, the system has global strong solution, and it converges to a flock. On the other hand, another set of initial conditions will lead to a finite time break down of the system. This is a joint work with Eitan Tadmor. (Received March 05, 2013)

1090-35-396 **Sigurd B Angenent*** (angenent@math.wisc.edu), Department of Mathematics-UW Madison, 480 Lincoln Drive, Madison, WI 53706. *The Zoo of Solitons for Curve Shortening in \mathbb{R}^n* . Preliminary report.

(joint work with Dylan Altschuler, Steve Altschuler, and Lani Wu) Curve shortening describes the motion of plane or space curves in the direction of their curvature vector. Special solutions whose evolution under curve shortening is given by rotation, dilation, translation, or a combination of these are called self similar. Self similar solutions to curve shortening in the plane are well known to be either circles or Abresch-Langer curves. In higher dimensions the variety of self similar solutions turns out to be much larger. I will give an overview of the different kinds of solutions that exist. Many of these solutions were first found by numerical simulation. The effort to prove existence of solutions like the ones found in numerical simulations led to some general theorems about self similar solutions, and also to a few solutions that cannot be found by numerics. (Received March 05, 2013)

1090-35-430 **Alexis F. Vasseur*** (vasseur@math.utexas.edu), **Kyudong Choi** and **Nicholas Leger**. *Relative entropy, stability of shocks for conservation laws, and applications to asymptotic limits*.

We study the L^2 stability, up to a translation, of extremal entropic shocks, with possible large amplitude, to systems of conservation laws, among bounded entropic weak solutions. The method is based on relative entropy. We provide first applications of the method to the study of asymptotic limits. (Received March 05, 2013)

1090-35-437 **Baskar Ganapathysubramanian***, Iowa State University, Ames, IA 50010. *Modeling evaporation & phase-separation in thin film evaporation: Cahn-Hilliard-Cook equations, adaptive time-stepping and Linear stability analysis*.

We develop a predictive computational framework to model morphology evolution during solvent-based fabrication of thin films. We focus on two distinct physical phenomena: evaporation and phase separation. We formulate this multi-physics problem using a phase field approach using a set of three phase field variables to represent the volume fraction of solvent, and the two solutes that determine the final morphology. We detail the challenges faced in numerically solving this set of stochastic equations. A primary challenge is related to the multiple temporal and spatial scales inherent in this transient non-linear problem. By focusing on the two sources of multiple temporal and spatial scales – one determined by phase separation, and the other driven by the dynamics of evaporation – we leverage adaptive space-time strategies. We address several numerical challenges and show how a computationally efficient approach augments experiments and provides predictions at levels close to device scale. (Received March 06, 2013)

37 ► *Dynamical systems and ergodic theory*

1090-37-48 **Rodrigo Trevino*** (rtrevino@math.cornell.edu), Ithaca, NY 14850. *Recent developments on the ergodicity of translation flows on flat surfaces*.

I will discuss some recently-developed criteria for ergodicity of translations flows on flat surfaces of finite area. These include results for non-compact (infinite genus) surfaces, as well as results related to optimal escape rates of Teichmuller orbits from moduli space. (Received January 29, 2013)

1090-37-59 **Amanda Ludes**, **Celeste Mott** and **Dora Matache*** (dmatache@unomaha.edu), University of Nebraska at Omaha, Mathematics, Durham Science Center 203, Omaha, NE 68182. *Phase Transition of Heterogeneous Boolean Networks with Applications to Signal Transduction*. Preliminary report.

In this talk we consider a heterogeneous random Boolean network in which nodes obey several different types of Boolean functions. The ensemble of Boolean functions is partitioned in several categories including threshold functions, canalizing functions with one canalizing input, canalizing functions with two canalizing inputs, and biased functions. Recent research has focused on finding phase transitions under homogeneous ensembles with only one type of Boolean function. However, real networks, such as biological signal transduction networks, are comprised of several different types of Boolean functions in various proportions, and nodes from one class may be linked to nodes from a different class. We compute the average influence of functions for the heterogeneous network in terms of the network parameters. The critical condition which separates the phase space into ordered versus chaotic regions is provided. Simulation results indicate that the critical condition follows closely the separation of the phase plane obtained for simulated heterogeneous networks. The theoretical results are paired with an application to a signal transduction network of a generic fibroblast cell. Avenues for further research are presented as well. (Received February 07, 2013)

1090-37-60 **David Fried, Sebastian M Marotta and Rich L Stankewitz*** (rstankewitz@bsu.edu), Muncie, IN 47304. *Random Fibonacci dynamics and Caruso semigroups.*

A random dynamics variant of the Fibonacci sequence $1, 1, 2, 3, 5, 8, 13, 21, \dots$ leads to the dynamics of Caruso's family, a specific one-parameter family of Mobius semigroups. We discuss the conditions which imply that an attractor set exists (for generic Mobius semigroups and for specific Caruso semigroups) and present a preliminary investigation of the parameter plane based on topological consideration of certain invariant sets. (Received February 07, 2013)

1090-37-67 **Alastair N Fletcher***, fletcher@math.niu.edu. *The fast escaping set of a quasiregular mapping.*

The fast escaping set of a transcendental entire function is an object that has received a lot of recent attention in complex dynamics. The natural extension of holomorphic functions to higher real dimensions is the class of quasiregular mappings. In the spirit of extending ideas from complex dynamics to higher dimensions, we will discuss the fast escaping set $A(f)$ for quasiregular mappings of transcendental type. We will see that there are various equivalent ways to define $A(f)$, and we will see some examples where $A(f)$ takes on various interesting structures, such as hairs or spider's webs. This talk is based on joint work with David Drasin (Purdue) and Walter Bergweiler (Kiel). (Received February 13, 2013)

1090-37-81 **Atanas Stefanov*** (stefanov@math.ku.edu), 1460, Jayhawk Blvd, Department of Mathematics, University of Kansas, Lawrence, KS 66045, and **Todd Kapitula** (tkapitula@gmail.com). *Hamiltonian-Krein instability index and applications.*

The Hamiltonian-Krein (instability) index is concerned with determining the number of unstable eigenvalues for an operator in the form JL , where J is skew-symmetric and L is self-adjoint. If J has a bounded inverse, the theory is well-developed. There is however an important class of problems, for which J fails to have a bounded inverse. We overcome this difficulty by considering an equivalent eigenvalue problem, where J does have a bounded inverse, namely the Hilbert transform. We use the index to characterize the spectral stability of homoclinic traveling waves for fractional KdV and BBM type problems. (Received February 18, 2013)

1090-37-207 **Bruce Kitchens*** (bkitchens@math.iupui.edu), Department of Mathematical Sciences, 402 N. Blackford St., LD270, Indianapolis, IN 46202. *Ledrappier's example and some open problems in algebraic \mathbb{Z}^d dynamics.*

Ledrappier's 3-dot example will be discussed and the general framework for examining expansive \mathbb{Z}^d -actions by automorphism of compact groups will be explained. Then some further examples and open problems concerning closed, invariant subsets and properties of invariant measures will be presented. (Received March 01, 2013)

1090-37-257 **K. Parwani***, 600 Lincoln Avenue, Charleston, IL 61920. *Fixed points of nilpotent actions on surfaces.* Preliminary report.

Let S be a closed, orientable surface with genus greater than one and let $Diff^1(S)_0$ be the group of C^1 -diffeomorphisms of S that are isotopic to the identity. If N is a finitely generated nilpotent subgroup of $Diff^1(S)_0$, then fixed-point set of N is nonempty. (Received March 03, 2013)

1090-37-277 **Alex Wright***, amwright@math.uchicago.edu. *$SL(2, \mathbb{R})$ orbit closures of translation surfaces.*

We will discuss some recent results on the structure of $SL(2, \mathbb{R})$ orbit closures in the moduli space of translation surfaces. New connections will be presented between the flat geometry of a translation surface and the structure of its orbit closure. (Received March 03, 2013)

1090-37-344 **David Aulicino*** (aulicino@math.uchicago.edu). *Some Results on Affine Manifolds in Genus 3 with a Zero Lyapunov Exponent.* Preliminary report.

I will introduce the Lyapunov exponents of the Teichmüller geodesic flow on the moduli space of Abelian differentials and give some background on what is known about them. In genus 3, there are at most two Lyapunov exponents of the Kontsevich-Zorich cocycle that are non-trivial, in the sense that they cannot be explicitly computed for all affine invariant manifolds. It was proven that there is exactly one surface whose $SL(2, \mathbb{R})$ orbit has the property that both of these exponents are zero. We consider the problem of exactly one of these exponents being zero and present progress on what is known. (Received March 04, 2013)

1090-37-355 **Ioannis Konstantoulas*** (konstan2@illinois.edu). *Exponential decay of multiple mixing integrals of $SL(n)$ actions.*

Given a measure preserving, mixing action of $SL(n, \mathbb{R})$ on a probability space X , we show explicit decay for the correlation integrals of bounded, $SO(n)$ -finite functions on X ; this result generalizes the classical exponential

decay bound for matrix coefficients of unitary representations in the $SL(n)$ case. If time permits, we will also indicate extensions to arbitrary local fields and more general algebraic groups. (Received March 04, 2013)

1090-37-367 **E. Arthur Robinson, Jr., Joseph Rosenblatt and Ayse A Sahin*** (asahin@depaul.edu). *Directional mixing properties of \mathbb{Z}^2 actions*. Preliminary report.

We consider directional mixing properties of two commuting \mathbb{Z} actions. We extend the notion of mixing and weak mixing to arbitrary directions (not necessarily rational) via continuous extensions of the discrete action and we show that the directional behavior is related to the spectral properties intrinsic to the generators of the \mathbb{Z}^2 action. (Received March 04, 2013)

1090-37-368 **Ilya Gekhtman*** (igekhtman@uchicago.edu), 5837 South Blackstone Ave, Chicago, IL 60637. *Patterson-Sullivan Theory and Orbit Counting for Subgroups of Mapping Class Groups*.

We develop an analogue of Patterson-Sullivan theory for convex co compact subgroups of mapping class groups acting on the sphere of projective measured foliations and use it to compute exact multiplicative asymptotics for orbit growth of such groups in Teichmüller space and growth of conjugacy classes of Pseudo-Anosov elements in these groups of bounded dilatation. I may also indicate some results in that direction for more general nonelementary subgroups of mapping class groups. (Received March 04, 2013)

1090-37-377 **Svetlana Katok and Ilie Ugarcovici*** (iugarcov@depaul.edu). *Fuchsian groups and generalized Bowen-Series transformations*. Preliminary report.

Bowen and Series (1979) constructed a Markov map on the unit circle that is orbit equivalent to the action of a given cofinite Fuchsian group Γ . Such a construction relies on a well chosen fundamental domain for Γ in the Poincaré disk and a partition of its boundary by the endpoints of the isometric circles of the generators of Γ . We investigate generalized versions of this type of transformations associated to arbitrary partitions of the boundary circle, and show how several dynamical properties can be obtained from geometric considerations about their two-dimensional extensions. (Received March 05, 2013)

1090-37-406 **Kelly B Yancey*** (kbyancey1@gmail.com). *Typical Homeomorphisms*.

In a paper by Glasner and Maon in 1989 they introduce the idea of uniform rigidity as a topological analogue of classical rigidity in ergodic theory. This seems to be the correct topological analogue as similar generic properties hold in both settings. In this talk I will discuss how to produce generic homeomorphisms of the two torus and the Klein bottle that are weakly mixing and uniformly rigid. We will examine the different approaches for each compact manifold and why they are different. (Received March 05, 2013)

42 ► *Fourier analysis*

1090-42-309 **Eric Weber*** (esweber@iastate.edu), 396 Carver Hall, Department of Mathematics, Ames, IA 50011, **Dorin Dutkay** (dorin.dutkay@ucf.edu), 4000 Central Florida Blvd, P.O. Box 161364, Orlando, FL 32816, and **Deguang Han** (deguang.han@ucf.edu), 4000 Central Florida Blvd, P.O. Box 161364, Orlando, FL 32816. *Fourier Series and Cantor Sets*.

The traditional Cantor middle third set and some of its variations are attractor sets for iterated function systems. Those IFS's also give rise to invariant measures supported on those sets. We investigate the possibility of Fourier Series expansions with respect to those invariant measures. (Received March 04, 2013)

46 ► *Functional analysis*

1090-46-66 **Jonathan Henry Brown*** (brownjh@ksu.edu). *Simplicity of étale groupoid C^* -algebras*.

In 1980, Renault showed that if a locally compact Hausdorff étale groupoid is topologically principal and minimal then the groupoid C^* -algebra is simple. In this talk I present the converse of this result which was obtained in a recent paper with Lisa Clark, Cynthia Farthing and Aidan Sims. Our result generalizes the characterizations of simplicity for graph C^* -algebras, k -graph C^* -algebras and discrete transformation groups. We improve on the characterization of simplicity of Exel crossed products associated to covering maps of compact spaces obtained by Exel and Vershik. (Received February 12, 2013)

1090-46-158 **Waleed K. Al-Rawashdeh*** (walrawashdeh@mtech.edu), 1300 W. Park Street, Butte, MT 59701. *Weighted Composition Operators between Weighted Bergman and S^p Spaces.*

Let φ be an analytic self-map of open unit disk \mathbb{D} and ψ is analytic on \mathbb{D} . Then a weighted composition operator induced by φ with weight ψ is given by $(W_{\psi, \varphi} f)(z) = \psi(z)f(\varphi(z))$ for z in \mathbb{D} and f analytic on \mathbb{D} . For each $p \geq 1$, let S^p be the space of analytic functions on \mathbb{D} whose derivatives belong to the Hardy space H^p . For $\alpha > -1$ and $p > 0$ the weighted Bergman space A_α^p consists of all analytic functions in $L^p(\mathbb{D}, dA_\alpha)$, where $dA_\alpha(z) = \frac{(1+\alpha)}{\pi} (1 - |z|^2)^\alpha dA(z)$ is the normalized weighted area measure. In this talk, by using Carleson measure, we characterize boundedness and compactness of weighted composition operators act between weighted Bergman A_α^p and S^q spaces for $1 \leq p, q \leq \infty$. (Received February 27, 2013)

1090-46-174 **Allan P Donsig*** (adonsig1@unl.edu) and **David Milan** (dmilan@uttyler.edu). *Covers in Inverse Semigroups and Tight C^* -algebras.* Preliminary report.

Exel's tight representation of an inverse semigroup can be described using the natural partial order of the inverse semigroup. Using this alternative approach, we show that the C^* -algebra of a finitely-aligned category of paths, developed by Spielberg, is the tight C^* -algebra of a natural inverse semigroup. In particular, for a finitely-aligned higher-rank graph Λ , the tight C^* -algebra of the inverse semigroup associated to Λ is the same as the C^* -algebra of Λ . (Received February 28, 2013)

1090-46-235 **Hamed Mohd Obiedat*** (hobiedat@hu.edu.jo), The Hashemite University, Department of Mathematics, P.O.Box 150459, Zarqa, 13115, Jordan. *(w_1, w_2)-tempered ultra distributions representation theorems.*

We prove topological characterizations of the space $S(w_1, w_2)$ of test functions of tempered ultra distribution via the Fourier transform and the short-time Fourier transform. We use this characterizations and classical Riesz representation theorem to prove representation theorems for (w_1, w_2) -tempered ultra distributions. Moreover, we investigate the action of operator semigroups on (w_1, w_2) -tempered ultra distributions. (Received March 02, 2013)

1090-46-415 **Jonathan H Brown, Gabriel Nagy and Sarah A Reznikoff*** (sarahrez@math.ksu.edu), 138 Cardwell Hall, Department of Mathematics, Manhattan, KS 66506. *States on k -Graph C^* -algebras.* Preliminary report.

K -graphs, higher-rank analogues of directed graphs, were introduced by Kumjian and Pask last decade for application to the study of higher-rank C^* -algebras. We review the basic properties of these combinatorial objects and describe a collection of elements in the corresponding C^* -algebras analogous to the "abelian core" of an ordinary graph algebra. Our main theorem concerns unique extension properties of states on k -graph C^* -subalgebras. (Received March 05, 2013)

47 ► Operator theory

1090-47-27 **Semyon N. Litvinov*** (sn12@psu.edu), Department of Mathematics, Pennsylvania State University Hazleton, 76 University Drive, Hazleton, PA 18202. *On Individual Ergodic Theorems in Non-commutative L^p -spaces for $p > 1$.*

The notion of uniform equicontinuity in measure at zero for sequences of additive maps from a normed space into the space of measurable operators associated with a semifinite von Neumann algebra is discussed. It is shown that uniform equicontinuity in measure at zero on a dense subset implies the uniform equicontinuity in measure at zero on the entire space. This property is then applied to derive some individual ergodic theorems in non-commutative L^p -spaces with $p > 1$. (Received January 15, 2013)

1090-47-49 **Palle E T Jorgensen*** (palle-jorgensen@uiowa.edu), MLH 14, Dept Mathematics, University of Iowa, Iowa City, IA 52242. *Infinite products.* Preliminary report.

We give an operator theoretic construction of infinite product measures in a general setting that includes wavelet analysis of IFSs, but our approach includes continuous stochastic processes as well. For motivation, recall (Dutkay-Jorgensen), that to every affine function system with fixed scaling matrix, and a fixed set of translation points in R^n , we may associate a solenoid Sol. By this we mean a measure space whose L^2 space includes $L^2(R^n)$ in such a way that R^n embeds densely in Sol. (In the more familiar case of $n = 1$, we speak of a dense curve in an infinite-dimensional "torus." The latter being a geometric model of the solenoid.) The need for this generality arose in our earlier investigations, for example in the building of wavelet systems on L^2 spaces of Cantor measures, of which the affine IFSs are special cases. In these cases we found that one must pass to a suitable L^2 space of a solenoid. Indeed we showed that such wavelet bases fail to exist in the usual receptor

Hilbert space $L^2(R^n)$ from wavelet theory. The construction we offer here encompasses non-commutative cases built on endomorphisms in C^* -algebras. (Received January 31, 2013)

1090-47-107 **Olga Y. Kushel*** (kushel@math.tu-berlin.de), TU Berlin, Strasse des 17 Juni 136, Institut für Mathematik, Sekr. MA 4-2, 10623 Berlin, Germany. *Eventual total positivity and related properties.*

Eventually totally positive and eventually totally J -sign-symmetric matrices are studied. We mainly focus on their spectral properties, their sign patterns and special examples of such matrices. We also study D -positivity of matrices, i.e. the property of preserving the positivity of spectra under left multiplication by a diagonal matrix D with positive principal diagonal entries. (Received February 22, 2013)

1090-47-131 **M. Anoussis** and **A. Katavolos*** (akatavol@math.uoa.gr), Department of Mathematics, University of Athens, GR 15784 Athens, Greece, and **I. G. Todorov**. *Subspaces of $vN(G)$ and bimodules over maximal abelian selfadjoint algebras.* Preliminary report.

We study weak- $*$ closed masa-bimodules generated by $A(G)$ -invariant subspaces of $vN(G)$. An annihilator formula is established, which is used to characterise the weak- $*$ closed subspaces of $B(L^2(G))$ which are invariant under both Schur multipliers and the action of $M(G)$ via completely bounded maps. We study the special cases of extremal ideals having a given null set and, for a large class of groups, establish a link between relative spectral synthesis and relative operator synthesis. (Received February 25, 2013)

1090-47-141 **Kenneth R. Davidson*** (krdavids@uwaterloo.ca), Pure Mathematics Dept, University of Waterloo, Waterloo, ON N2L3G1, Canada, and **Elias G. Katsoulis** (katsoulise@ecu.edu), Department of Mathematics, East Carolina University, Greenville, NC 27858. *Dilation theory, commutant lifting and semicrossed products.*

We take a new look at dilation theory for nonself-adjoint operator algebras. Among the extremal (co)extensions of a representation, there is a special property of being fully extremal. This allows a refinement of some of the classical notions which are important when one moves away from standard examples. We show that many algebras including graph algebras and tensor algebras of C^* -correspondences have the semi-Dirichlet property which collapses these notions and explains why they have a better dilation theory. This leads to variations of the notions of commutant lifting and Ando's theorem. This is applied to the study of semicrossed products by automorphisms, and endomorphisms which lift to the C^* -envelope. In particular, we obtain several general theorems which allow one to conclude that semicrossed products of an operator algebra naturally imbed completely isometrically into the semicrossed product of its C^* -envelope, and the C^* -envelopes of these two algebras are the same. (Received February 26, 2013)

1090-47-142 **Paul S. Muhly*** (pmuhly@gmail.com), Department of Mathematics, University of Iowa, Iowa City, IA 52242, and **Baruch Solel** (mabaruch@technion.technion.ac.il), Department of Mathematics, Technion, 32000 Haifa, Israel. *Tensor Algebras, Intertwiners and Taylor's Taylor Series.*

We discuss how Joe Taylor's notion of matricial functions can be used to study Brook Taylor's Taylor series for elements of operator tensor algebras. These series arise naturally when one views the tensor algebra as a space of functions defined on the algebra's space of completely contractive representations. (Received February 26, 2013)

1090-47-144 **Elias G Katsoulis***, Department of Mathematics, East Carolina University, Greenville, NC 27858. *Piecewise conjugacy as an isomorphism invariant for operator algebras.* Preliminary report.

The concept of piecewise conjugacy for classical multivariable dynamical systems arose from the work of Davidson and Katsoulis on non-selfadjoint operator algebras and their isomorphisms. Due to the work of Cornelissen and Marcolli, non-selfadjoint operator algebras and piecewise conjugacy are now proven to be important beyond Functional Analysis. In this talk we will review several results from the original work of Davidson and Katsoulis on piecewise conjugacy for classical dynamical systems. We will also present a recent generalization of piecewise conjugacy for multivariable C^* -dynamical systems, due to Kakariadis and Katsoulis. We will show that this "generalized" piecewise conjugacy continues to be an isomorphism invariant for certain operator algebras associated with such systems. We will also discuss the completeness of piecewise conjugacy as an isomorphism invariant. (Received February 26, 2013)

1090-47-189 **Jan Cameron** and **David R. Pitts*** (dpitts2@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588, and **Vrej Zarikian**. *Bimodules over Cartan Algebras in von Neumann Algebras and an Assertion of Mercer.*

In a 1991 paper, R. Mercer asserted that a Cartan bimodule isomorphism between Cartan bimodule algebras \mathcal{A}_1 and \mathcal{A}_2 extends uniquely to a normal $*$ -isomorphism between the von Neumann algebras generated by \mathcal{A}_1 and \mathcal{A}_2 . Mercer's argument relied on the spectral theorem for σ -weakly closed bimodules over a Cartan MASA in a von Neumann algebra. Unfortunately, due to a gap in the proof of the spectral theorem for bimodules, its validity for non-hyperfinite von Neumann algebras is unknown at present. Thus a complete proof of Mercer's assertion requires a new approach.

In this talk, I will discuss a spectral theorem for Bures closed bimodules, which together with the use of norming algebras (in the sense of Pop-Sinclair-Smith), provides that approach. In addition to leading to a proof of Mercer's assertion, our perspective leads to a number of interesting observations, including a new proof of a theorem of Aoi, and the fact that any Cartan MASA in a von Neumann algebra \mathcal{M} norms \mathcal{M} . (Received March 01, 2013)

1090-47-192 **Raul E. Curto*** (raul-curto@uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52242. *Quasinormal Toeplitz operators with matrix-valued rational symbols.*

Let $T \equiv VP$ be the canonical polar decomposition of a Hilbert space operator. T is said to be *quasinormal* if T commutes with T^*T ; or equivalently, if the C^* -algebra generated by V and P is abelian. We study quasinormality and subnormality of Toeplitz operators with matrix-valued rational symbols. In particular, in view of Halmos's Problem 5, we focus on the question: Which subnormal Toeplitz operators are normal or analytic?

In joint work with In Sung Hwang and Woo Young Lee, we first prove that every pure quasinormal operator with finite rank self-commutator is unitarily equivalent to a Toeplitz operator with matrix-valued analytic rational symbol. Next, we show that every pure quasinormal Toeplitz operator with matrix-valued rational symbol is unitarily equivalent to an analytic Toeplitz operator. To illustrate our main result, we provide a revealing example: the solution of a subnormal Toeplitz completion problem. (Received February 28, 2013)

1090-47-201 **Evgenios Kakariadis*** (ekakaria@uwaterloo.ca). *C^* -dynamical systems and Operator Algebras.*

The (usual) C^* -crossed product may be seen as the natural C^* -algebra arising from an automorphic C^* -dynamical system. When the system is no longer automorphic, though, there is a significant number of such possible candidates, i.e., generalized C^* -crossed products. Following Stacey, the main scheme is to relate each one of them to (a full corner of) a usual C^* -crossed product. The first objective of this talk will be to present several obstructions to this task.

Another candidate arises in the context of "Arveson's Program on the C^* -envelope". This is the C^* -envelope of an appropriate non-selfadjoint operator algebra, e.g., of a semicrossed product, of a tensor algebra etc. The second objective of this talk will be to present certain advantages of this approach and of the use of these non-selfadjoint operator algebras. In particular we will comment on their flexibility and on the fact that they capture the structure of the dynamics.

(The talk is based on joint works with Ken Davidson, Elias Katsoulis and Justin Peters) (Received March 01, 2013)

1090-47-310 **Adam H. Fuller*** (afuller7@math.unl.edu), University of Nebraska - Lincoln, and **David R. Pitts**, University of Nebraska - Lincoln. *The Lattice of Bures-Closed Bimodules in Cartan Pairs.*

Let M be a von Neumann algebra and let D be a Cartan maximal abelian subalgebra of M . The study of the σ -weakly closed D -bimodules in M has been a topic of interest for quite sometime.

Recently, Cameron, Pitts and Zarikian have established a connection between the σ -weakly closed D -bimodules and the less familiar Bures-closed D -bimodules.

In this talk, we continue the study of the Bures-closed bimodules. In particular, when M is separably acting and D is diffuse, we show that the lattice of Bures-closed bimodules has very little to do with the von Neumann algebra M . The case when D has atomic projections will also be discussed.

This is joint work with David R. Pitts. (Received March 04, 2013)

49 ► *Calculus of variations and optimal control; optimization*

1090-49-79 **Matthew Badger*** (badger@math.sunysb.edu), Stony Brook University, Department of Mathematics, Stony Brook, NY 11794-3651. *Extremal metrics for extremal length and modulus of measures.*

For each $1 \leq p < \infty$, we formulate a necessary and sufficient condition for an admissible metric to be extremal for the Fuglede p -modulus of a system of measures. When $p = 2$, this characterization generalizes Beurling's criterion, a sufficient condition for an admissible metric to be extremal for the extremal length of a planar curve family. (Received February 18, 2013)

51 ► *Geometry*

1090-51-3 **Vladimir Markovic**, California Institute of Technology, Department of Mathematics, Pasadena, CA. *Virtual classification of 3-manifolds.*

I will discuss the recently established “virtual” classification of three manifolds, focusing on the case of hyperbolic manifolds. (Received March 18, 2012)

1090-51-51 **G. Eric Moorhouse** and **Tim Penttila*** (penttila@math.colostate.edu), Department of Mathematics, Colorado State University, Fort Collins, CO 80523. *Groups of projective planes with differing numbers of point and line orbits.*

An open problem, popularized by Peter Cameron in 1984 and 1994 (and attributed by him to Bill Kantor), concerning collineation groups of projective planes is solved. The origin of the problem lies in a 1941 result of Richard Brauer, rediscovered at least three times (by Peter Dembowski in 1958, Dan Hughes in 1957, and by Ernest Tilden Parker in 1957) that a collineation group of a *finite* projective plane has equally many orbits on points and on lines. All the known proofs require finiteness, so the problem raised by Cameron (and Kantor) is whether every collineation group of an infinite projective plane need have equally many orbits on points and on lines.

Counterexamples in the infinite case to a more general 1967 lemma of Richard Block that the number of orbits of an automorphism group of a finite 2-design on blocks is greater than or equal to the number of orbits of that group on points have been known since 1999 (due to Bridget Webb, Alan Camina and David Evans).

But, until now, that question for infinite projective planes has remained open. Here we settle that question in the negative, even for infinite *Desarguesian* projective planes. (Received February 05, 2013)

1090-51-90 **Kyle E Kinneberg*** (kkinneberg@math.ucla.edu). *Entropy rigidity in coarse geometry.*

A common theme in Riemannian geometry is the analysis of metrics that are extremal for a given functional. In the 1990s, several important results in this direction were established for negatively curved manifolds. Among them was the entropy-rigidity theorem of Hamenstädt: if a closed manifold of curvature bounded above by -1 admits a locally symmetric metric, then the volume-growth entropy is minimized precisely by the locally symmetric metrics. This result was subsequently adapted to the setting of metric geometry by the work of Bourdon and Bonk–Kleiner, who studied rigidity of geometric group actions on $\text{CAT}(-1)$ spaces. In this talk, I will discuss analogous results in the coarse setting, namely, rigidity for geometric group actions on Gromov hyperbolic metric spaces with a suitable upper curvature bound. (Received February 27, 2013)

1090-51-343 **Ferry Henrik Kwakkel*** (kwakkel@ime.usp.br), Instituto de Matemática e Estatística, Rua do Matão, 1010 - Cidade Universitária, CEP 05508-090, Sao Paulo, Sao Paulo, Brazil. *Projective structures on closed surfaces and the geometry of diffeomorphisms.*

Quasiconformal Teichmüller theory, a subject of much historical and contemporary interest, centers around the idea of understanding moduli spaces of marked conformal structures on a closed surface through the use of quasiconformal mappings. The theory presents a rich interplay between analysis, geometry and topology performed on the underlying Riemann surfaces.

Analogously, I will discuss the notion of quasiprojective Teichmüller space, which can be seen as a natural second-order analogue of quasiconformal Teichmüller space, in the sense that the deviation of a diffeomorphism from being an isometry is now measured up to second order, rather than up to first order. This notion of distortion, called bending, is used to parametrize Teichmüller space from this perspective and is aimed at understanding the finite-dimensional space of convex projective structures on a closed surface, of which classical Teichmüller space is a natural subspace.

We presents results relating quasiconformal Teichmüller space and quasiprojective Teichmüller space, and we study its global geometry and topology. Current work focuses on precise deformations of projective structures through special quasiprojective representatives of a homotopy class, of which we give concrete examples. (Received March 04, 2013)

1090-51-436 **Michael J. Lindsey*** (lindsey3@stanford.edu), **Yanir Rubinstein**, **Otis Chodosh**, **Vishesh Jain** and **Lyuboslav Panchev**. *Visualizing optimal transportation maps*. Preliminary report.

Given two sufficiently regular probability measures μ and ν on \mathbb{R}^n , general results due to Brenier (1987) guarantee the existence and uniqueness of an optimal transportation map between them, that is a map $T : \mathbb{R}^n \rightarrow \mathbb{R}^n$ such that $T\#\mu = \nu$ and the quadratic cost $\int_{\mathbb{R}^n} |T(x) - x|^2 d\mu(x)$ is minimized. However, in general it is hard to say much about the map, let alone give an explicit expression for it. We present an efficient computer algorithm that uses a discretization of the problem to give perhaps the first pictures and movies of optimal transportation plans, for domains in \mathbb{R}^2 . These suggest subtle relations between the geometry of the support μ and ν and the regularity of T , some of which we are able to prove. (Received March 06, 2013)

52 ► Convex and discrete geometry

1090-52-297 **Andrea N Young*** (younga@ripon.edu), 300 Seward St, Ripon, WI 54971. *A Discrete Yamabe Problem*.

In this talk, I will discuss Einstein metrics, constant scalar curvature metrics, and the Yamabe problem on piecewise flat manifolds. The main tool is analysis of Regge's Einstein-Hilbert functional, a piecewise flat analogue of the Einstein-Hilbert (or total scalar curvature) functional on Riemannian manifolds. I will discuss the Einstein-Hilbert-Regge functional on the space of metrics and on discrete conformal classes of metrics. Known results and work in progress will be presented. (Received March 04, 2013)

53 ► Differential geometry

1090-53-148 **Mao-Pei Tsui*** (mao-pei.tsui@utoledo.edu), Department of Mathematics and Statistics, The University of Toledo, 2801 W. Bancroft St, Toledo, OH 43606. *The Curvature Estimate Of Higher Codimensional Mean Curvature Flow*. Preliminary report.

K. Ecker and G. Huisken have derived a priori estimate for the curvature (second fundamental forms) when they study the mean curvature flow of the graph of a function in Euclidean space. In this talk, I will explain that a similar curvature estimate also exists for higher codimensional mean curvature flow under certain natural conditions. This is joint work with Knut Smoczyk and Mu-Tao Wang. (Received February 26, 2013)

1090-53-165 **Robert Gulliver*** (gulliver@math.umn.edu). *Branch points of minimizing projective planes*.

The construction of minimal surfaces in a Riemannian manifold is accomplished by minimizing energy under Plateau boundary conditions. The minimizer is a conformally parameterized surface with possible isolated singularities, called *branch points*. True branch points are those which are locally not a branched covering of an immersed surface. They are only possible on an area-minimizing minimal surface when the codimension is at least 2. The absence of false branch points, or more generally of ramified branch points, requires a global topological hypothesis, the Douglas hypothesis; but that has so far only been shown to suffice for orientable surfaces. A branch point is *ramified* if in every neighborhood of the point there are two open sets which define the same piece of surface. In this talk, we will outline these arguments for oriented surfaces, extend a basic theorem to nonorientable surfaces, and then discuss minimal surfaces defined on the projective plane. This requires an application of the Riemann-Hurwitz formula. We will show that in codimension one, a mapping from the projective plane, which minimizes area among homotopically non-trivial mappings, is an immersion. (Received February 27, 2013)

1090-53-237 **Mihai Bailesteanu*** (mbailest@z.rochester.edu), Rochester, NY 14620. *A reduction theorem for Spin(7) manifolds*. Preliminary report.

Spin(7) manifolds are special holonomy manifolds, which can be characterized as Riemannian manifolds endowed with a special 4-form. In viewing this 4-form as an analog of a symplectic form, one may explore the possibility

of building a moment map and a reduction space. We will discuss how this moment map is defined and how one can characterize the reduction space. (Received March 02, 2013)

1090-53-366 **Bianca Santoro*** (bsantoro@ccny.cuny.edu), 138th St and Convent Avenue, NAC 4/112B, Mathematics Department, New York, NY 10031. *Complete Ricci-flat Kahler metrics on resolutions of singularities.*

We will discuss some existence results for complete Calabi-Yau metrics on crepant resolutions of singularities, and use these results to give simple examples of ALF Ricci-flat manifolds. (Received March 04, 2013)

1090-53-379 **Michael Jablonski*** (mjablonski@math.ou.edu), Department of Mathematics, University of Oklahoma, Norman, OK 73019-3103. *Maximal symmetry in solvmanifolds.* Preliminary report.

A Riemannian metric is said to have maximal symmetry if its isometry group contains the isometry group of any other metric (up to conjugation). In this talk, we will discuss the existence of maximal symmetry metrics among left-invariant metrics on Lie groups. (Received March 05, 2013)

1090-53-403 **Lu Wang*** (lwang@math.jhu.edu), 3400 N. Charles Street, Baltimore, MD 21218. *Rigidity of Self-similar Solutions of Geometric Flows.*

Self-similar solutions of geometric flows usually model a large class of singularities of the flows and thus play an important role in the study of the flows. In this talk, we will discuss some recent progress in the rigidity (at infinity) of self-similar solutions of various geometric flows. (Received March 05, 2013)

57 ► Manifolds and cell complexes

1090-57-72 **Piotr Przytycki** and **Jennifer Schultens*** (jcs@math.ucdavis.edu), Dept of Math, UC Davis, 1 Shields Ave, Davis, CA 95618. *The Kakimizu complex of a knot.*

We define and give examples of the Kakimizu complex of a knot. We also discuss distance in the Kakimizu complex and how a certain projection map provides streamlined proofs of geometric and topological properties. (Received February 15, 2013)

1090-57-74 **David C Bachman*** (bachman@pitzer.edu), Pitzer College, 1050 N. Mills Ave, Claremont, CA 91711. *Normalizing Topologically Minimal surfaces.*

Topologically minimal surfaces generalize several well-studied classes of surfaces in 3-manifolds, and provide a topological analogue to geometrically minimal surfaces. We will discuss recent progress in obtaining a normal form for any such surface with respect to a fixed triangulation. This provides striking analogues with results of Colding and Minicozzi, and establishes finiteness results which are crucial to understanding how Heegaard splittings are effected by Dehn surgery. (Received February 16, 2013)

1090-57-76 **Michael Yoshizawa***, Department of Mathematics, University of California, Santa Barbara, Santa Barbara, CA 93106. *High Distance Heegaard Splittings via Dehn Twists.*

In 1987, A. Casson and C. Gordon showed that Dehn surgery on certain knots will produce strongly irreducible (distance at least 2) Heegaard splittings. These knots lie in a Heegaard surface of the original 3-manifold and are required to have distance at least 2 from the disk complexes of the two handlebodies. I will discuss a generalization of their result which gives upper and lower bounds on splittings obtained by Dehn surgery on higher distance knots. (Received February 16, 2013)

1090-57-99 **Charles Frohman*** (charles-frohman@uiowa.edu), Department of Mathematics, The University of Iowa, Iowa City, IA 52242. *Farey Diagrams, simple closed curves, and multiplication in the Kauffman bracket skein algebra of a punctured torus.*

In the 90's Frohman and Gelca derived the product to sum formula using noncommutative cosines that made computation in the Kauffman bracket skein algebra of a punctured torus tractable. Many people have sought to extend this mode of computation to the skein algebra of the punctured torus.

In this lecture I will introduce a cocycle on the Farey diagram that encodes the failure of the product to sum formula, explain elementary rules for its computation, and use it to give an elementary proof of a theorem of Bonahon and Wong about skein algebras at roots of unity. (Received February 21, 2013)

1090-57-138 **Christian R. Millichap*** (christian.millichap@gmail.com). *How many hyperbolic 3-manifolds can have the same volume?*

The work of Jørgensen and Thurston shows that there is a finite number $N(v)$ of orientable hyperbolic 3-manifolds with any given volume v . In this talk, we construct examples showing that the number of hyperbolic knot complements with a given volume v can grow at least factorially fast with v . A similar statement holds for closed hyperbolic 3-manifolds, obtained via Dehn surgery. Furthermore, we give explicit estimates for lower bounds of $N(v)$ in terms of v for these examples. These results improve upon the work of Hodgson and Masai, which describes examples that grow exponentially fast with v . Our constructions rely on performing volume preserving mutations along Conway spheres and on the classification of Montesinos knots. (Received February 26, 2013)

1090-57-160 **Ryan Blair, Marion Campisi, Jesse Johnson, Scott Taylor and Maggy Tomova*** (maggy-tomova@uiowa.edu), 14 MacLean Hall, Iowa City, IA 52240. *Progress on the Cabling Conjecture.*

In this talk I will discuss our recent results solving the Cabling Conjecture for all knots with a bridge surface of distance at least three. I will also discuss our results characterizing all knots with a bridge surface of distance two. Combining these results with already known facts about knots with bridge surfaces of distance one gives a characterization of all potential counterexamples to the Cabling Conjecture. (Received February 27, 2013)

1090-57-172 **Cheryl Balm*** (balmcher@math.msu.edu) and **Effie Kalfagianni**. *Cosmetic crossings and twisting operations in knots.*

An open question in knot theory asks when a crossing change in a knot diagram leaves the underlying knot unchanged. We will explore a related question involving generalized crossing changes in knots and show that the property of admitting no cosmetic crossing changes is preserved under the operation of inserting full twists in three or more strands of a knot. We will then discuss consequences of this result for some well-known classes of knots. (Received February 28, 2013)

1090-57-179 **Dorothy Buck, Kai Ishihara and Matt Rathbun*** (m.rathbun@imperial.ac.uk), Imperial College London, South Kensington Campus, 6M33 Huxley Building, London, W12 7BX, United Kingdom, and **Koya Shimokawa**. *Cutting Arcs and Band Surgeries in Fiber Surfaces.*

Fibered links are those whose complements fiber over the circle, with fibers that are copies of a Seifert surface for the link. It is known that every fiber surface for a link can be obtained from a disk by a sequence of operations called Hopf plumbing and its inverse de-plumbing. Both of these can be viewed as special cases of an operation on links called coherent band surgery. We investigate the problem of when cutting a fiber surface along an arc results in a fibered link. This allows us to generalize Hopf plumbing, and to characterize when two fibers are related by a band attachment. The solution to this problem has ramifications in Biology and understanding how certain enzymes interact with DNA. (Received February 28, 2013)

1090-57-181 **Ollie Nanyes*** (onanyes@bradley.edu), Department of Mathematics, Bradley University, 833 N. Cooper St., Peoria, IL 61606. *Invariants for some everywhere wild knots.* Preliminary report.

R. H. Bing discovered a simple closed curve which pierces no disk. A. Shilepsky studied wild knots that are obtained by a similar constructions (decreasing sequences of nested solid tori) and studied their homogeneity properties. H. G. Bothe developed some invariants for a subclass of the Shilepsky knots that pierce a disk at all of their points.

Here we strengthen Bothe's invariants and develop invariants for a subclass of the Bing-Shilepsky knots which pierce no disk at any of their points. (Received February 28, 2013)

1090-57-193 **Kentaro Ito*** (itoken@math.nagoya-u.ac.jp), Graduate School of Mathematics, Nagoya University, Nagoya, Aichi 464-8602, Japan. *Linear slices close to a Maskit slice.*

We consider linear slices of the space of Kleinian once-punctured torus groups; a linear slice is obtained by fixing the value of the trace of one of the generators. The linear slice for trace 2 is called the Maskit slice. We will show that if traces converge "horocyclically" to 2 then associated linear slices converge to the Maskit slice, whereas if the traces converge "tangentially" to 2 the linear slices converge to a proper subset of the Maskit slice. This result will be also restated by using the complex Fenchel-Nielsen coordinate. In addition, we will show that there is a linear slice which is not locally connected. (Received March 01, 2013)

1090-57-216 **R Sean Bowman*** (sean.bowman@okstate.edu). *Dehn surgery and bridge number of knots in handlebodies*. Preliminary report.

I will describe a family of knots in handlebodies which have nontrivial handlebody surgeries. The knots can be obtained by “twisting along an annulus.” We’ll examine the construction with an eye to approximating the bridge number and, as a result, see that there are knots in this family with arbitrarily high bridge number. (Received March 01, 2013)

1090-57-226 **Douglas J LaFountain*** (d-lafountain@wiu.edu) and **William W Menasco**. *Embedded annuli and Jones’ conjecture*.

We show that after stabilizations of opposite parity and braid isotopy, any two braids in the same topological link type cobound embedded annuli. We use this to prove the generalized Jones conjecture relating the braid index and algebraic length of closed braids within a link type, following a reformulation of the problem by Kawamuro. (Received March 02, 2013)

1090-57-254 **Scott A. Taylor*** (sataylor@colby.edu), **Byoungwook Jang**, **Pratap Luitel** and **Alexander Zupan**. *Almost unknotted graphs: theorems, examples, conjectures*. Preliminary report.

A θ -graph embedded in S^3 is *almost unknotted* or *Brunnian* if it is not isotopic to an unknotted graph and if it has the property that every knot obtained by removing an edge of the graph is an unknot. Kinoshita’s graph is the most famous example of an almost unknotted graph. I will discuss a few topological and algebraic properties of almost unknotted graphs stemming from recent work in sutured manifold theory and quandle theory. I will also show a new family of diagrams which we conjecture represent infinitely many distinct “prime” almost unknotted graphs. (Received March 03, 2013)

1090-57-262 **Jessica E. Banks*** (jessica.banks@lmh.oxon.org). *Seifert surfaces for split links and links in \mathbb{R}^3* .

The study of Seifert surfaces for links in S^3 has generally been restricted to non-split links. This is because the exterior of a split link is reducible, and many techniques for studying surfaces in 3-manifolds require the manifold to be irreducible. In this talk we will look at what we can say about Seifert surfaces for split links, and as part of this we will consider Seifert surfaces for non-split links in \mathbb{R}^3 . We will see that such a surface can be described up to isotopy by an isotopy class of Seifert surfaces for the link in S^3 together with an element of the fundamental group of the link exterior. (Received March 03, 2013)

1090-57-288 **Ken Baker**, **Brandy Guntel Doleshal*** (bdoleshal@shsu.edu) and **Neil Hoffman**. *Knots with two lens space surgeries*. Preliminary report.

John Berge introduced 12 families of knots that each permit a lens space surgery and conjectured that these are the only knots that admit lens space surgeries. We examine knots in S^3 that admit two nontrivial lens space surgeries. This is joint work with Ken Baker and Neil Hoffman. (Received March 04, 2013)

1090-57-291 **Yo’av Rieck*** (yoav@uark.edu), Department of Mathematical Sciences, 1 University Dr, University of Arkansas, Fayetteville, AR 72701, and **Yasuahi Yamashita**. *The link volume of hyperbolic 3-manifolds*.

The link volume is an invariant of closed orientable 3-manifolds that measures how efficiently a given manifold can be shown as a (branched) cover of S^3 . We will begin by recalling the definition of the link volume and stating some basic results about it. We will then explain why for every $V > 0$, there exists a hyperbolic manifold M , so that $\text{Vol}(M) < 2.03$ and $\text{LV}(M) > V$, where Vol is the hyperbolic volume and LV is the link volume. (Received March 04, 2013)

1090-57-292 **Rachel Roberts*** (roberts@math.wustl.edu) and **William H. Kazez**. *Gabai degeneracy and fractional Dehn twist coefficients*. Preliminary report.

We describe the relationship between Gabai degeneracy and fractional Dehn twist coefficients and use this relationship to make several observations. This is work joint with Will Kazez. (Received March 04, 2013)

1090-57-295 **Nicholas T Zufelt*** (nzufelt@math.utexas.edu). *Current Progress on the Two Summands Conjecture*. Preliminary report.

A topic of great interest in knot theory is that of obtaining a reducible manifold by Dehn surgery on a knot in S^3 . The cabling conjecture asserts that such a manifold can arise only when performing a specific surgery on a cable knot. In particular, reducible cable knot surgeries produce two prime connected summands. In light of this, a natural question to ask is: can Dehn surgery produce more than two nontrivial connected summands? In

this talk, we will discuss current progress on this question, in the form of a bound on the surgery slope in terms of the bridge number of the knot. (Received March 04, 2013)

1090-57-305 **Ryan Blair*** (ryblair@math.upenn.edu), Department of Mathematics, David Rittenhouse Lab, 209 South 33rd Street, Philadelphia, PA 19104-6395, and **Maggy Tomova** and **Dave Futer**. *Essential Surfaces in Highly Twisted Knot Extérieurs.*

Let K be a knot with reduced diagram D and let $d(D)$ be the minimal number of crossings in any twist region of D . We will present a linear function of $d(D)$ that gives a lower bound on the negative Euler characteristic of certain essential surfaces in the exterior of K . (Received March 04, 2013)

1090-57-311 **T F Schirmer*** (trent.schirmer@mail.okstate.edu). *A lower bound on the Heegaard genus of amalgamated 3-manifolds.*

I sketch my proof that if M is the amalgamation of two 3-manifolds M' and M'' along an incompressible torus which intersects a minimal genus Heegaard splitting of M in a "nice" way which I will describe, then $g(M) > \max(g(M'), g(M'')) - 2$. One consequence is that $t(K \# K') > \max(t(K), t(K')) - 1$ for pairs of knots in the 3-sphere, assuming one to be m -small. (Received March 04, 2013)

1090-57-348 **Mario Eudave-Muñoz*** (mario@matem.unam.mx), Instituto de Matemáticas, Universidad Nacional Autónoma de México, Ciudad Universitaria, 04510 México, DF, México, and **Enrique Ramírez-Losada**, Centro de Investigación en Matemáticas, AC, Callejón Jalisco S/N, Col. Valenciana, 36240 Guanajuato, Gto., México. *Klein bottles and tori properly embedded in a knot exterior.*

We show that there is an infinite family of knots with an unexpected property. In fact, for each knot k in the family there is an incompressible branched surface B properly embedded in the knot exterior, such that for each positive odd number n , there is an incompressible Klein bottle carried by B , whose boundary consists of n curves. Note that it was unknown whether there is a knot with a properly embedded Klein bottle with 3 boundary components. For each positive even number m , the branched surface B also carries an incompressible tori with m boundary components. All these surfaces have the same boundary slope and all survive Dehn surgery along that slope. (Received March 04, 2013)

1090-57-398 **John Luecke*** (luecke@math.utexas.edu), The University of Texas at Austin, Mathematics Department, 1 University Station C1200, Austin, TX 78712-0257, and **Ken Baker** and **Cameron Gordon**. *Genus two bridge number for a knot admitting an S^3 surgery.* Preliminary report.

Let M be a closed 3-manifold that admits a genus 2 Heegaard splitting. Let X be the exterior of K in M and assume that the interior of X is hyperbolic of finite volume. Let μ be a meridian of K on the boundary of X and γ be another homotopically non-trivial, simple closed curve on the boundary of X . Let $K(\gamma)$ be the Dehn filling of X along γ . Let $\Delta(\mu, \gamma)$ be the minimal geometric intersection of μ and γ up to isotopy on the boundary of X . Finally, and most importantly, assume that $K(\gamma)$ is S^3 . A result of Rieck (Topology **39** (2000)) shows that if $\Delta(\mu, \gamma) \geq 54$ then K can be isotoped onto any genus 2 Heegaard splitting of M . We show that often this lower bound on $\Delta(\mu, \gamma)$ can be significantly lowered if one is only interested in finding some genus 2 Heegaard surface for M onto which K can be isotoped. (Received March 05, 2013)

1090-57-438 **Benjamin A Burton**, **Alexander Coward*** (alexander.coward@gmail.com) and **Stephan Tillmann**. *Computing closed essential surfaces in knot complements.*

We determine which of the prime knots with at most 12 crossings contain a closed essential surface in its complement. The proof relies on an implementation of normal surface theory and many different methods, which we shall examine in this talk, that help make the algorithm practical. (Received March 06, 2013)

58 ► *Global analysis, analysis on manifolds*

1090-58-68 **Ovidiu Munteanu*** (ovidiu.munteanu@uconn.edu), Department of Mathematics, 196 Auditorium Road, Unit 3009, Storrs, CT 06269. *Holomorphic functions on certain Kahler manifolds.*

We discuss Liouville theorems and dimension estimates for the space of polynomially growing holomorphic functions on complete Kahler manifolds. In recent joint work with Jiaping Wang, we have obtained new results on this topic, which were motivated by the study of Ricci solitons in the theory of Ricci flow. However, the most general results that we have do not require any knowledge of curvature. (Received February 13, 2013)

1090-58-98 **Dragomir Saric*** (dragomir.saric@qc.cuny.edu), Queens College, Department of Mathematics, 65-30 Kissena Blvd., Flushing, NY 11367. *Deformations of hyperbolic structures via shears.*

Teichmüller spaces of infinite surfaces (including the Teichmüller space of the unit disk—the universal Teichmüller space) are considered. We discuss the shear coordinates for the infinite-dimensional Teichmüller spaces and compute the tangent vectors to the Teichmüller spaces as well as the complex structure of the Teichmüller spaces in terms of shear coordinates. (Received February 21, 2013)

60 ► *Probability theory and stochastic processes*

1090-60-8 **Amarjit Budhiraja, Jiang Chen*** (jiangc@live.unc.edu) and **Paul Dupuis**. *Large Deviations for Stochastic Partial Differential Equations Driven by a Poisson Random Measure.*

Stochastic partial differential equations driven by Poisson random measures (PRM) have been proposed as models for many different physical systems. A systematic framework for the study of probabilities of deviations of the stochastic PDE from the deterministic PDE is through the theory of large deviations. The goal of this work is to develop the large deviation theory for small Poisson noise perturbations of a general class of deterministic infinite dimensional models. Although the analogous questions for finite dimensional systems have been well studied, there are currently no general results in the infinite dimensional setting. This is in part due to the fact that in this setting solutions may have little spatial regularity, and thus classical approximation methods for large deviation analysis become intractable. The approach taken here, which is based on a variational representation for nonnegative functionals of general PRM, reduces the proof of the large deviation principle to establishing basic qualitative properties for controlled analogues of the underlying stochastic system. As an illustration of the general theory, we consider a particular system that models the spread of a pollutant in a waterway. (Received March 02, 2013)

1090-60-12 **Oren Louidor*** (louidor@math.ucla.edu), 535 Kelton Avenue, Apt 6, Los Angeles, CA 90024, and **Marek Biskup, Eviatar Procaccia** and **Ron Rosenthal**. *The extremal process for the discrete 2D Gaussian Free Field.*

We derive the distributional limit of the external process for the Discrete Gaussian Free Field with zero boundary conditions on the box $[1, N]^2$ when N tends to ∞ . Joint work with M. Biskup. (Received December 06, 2012)

1090-60-73 **Jonathon Peterson*** (peterston@math.purdue.edu), 150 N University St, West Lafayette, IN 47920. *Large deviations for random walks in a random environment on a strip.*

We consider large deviations of random walks in a random environment on the strip $\mathbb{Z} \times \{1, 2, \dots, d\}$. Large deviations for random walks in random environments have been studied in a variety of different types of graphs, but only in the one-dimensional nearest-neighbor case is there a known variational formula relating the quenched and averaged rate functions. We will generalize the argument for the one-dimensional case to that of a strip of finite width and prove quenched and averaged large deviation principles with a variational formula relating the two rate functions. The main novelty in our approach will be to use an idea of Furstenberg and Kesten to obtain probabilistic formulas for the limits of certain products of random matrices. (Received February 16, 2013)

1090-60-75 **Antonio Auffinger*** (auffing@uchicago.edu), Dept. of Mathematics, 5734 S. University Avenue, Chicago, IL 60637. *Geodesics in first-passage percolation.*

First-passage percolation is a model of a random metric on an infinite network. It deals with a collection of points which can be reached within a given time from a fixed starting point, when the network of roads is given, but the passage times of the road are random. It was introduced back in the 60's but most of its fundamental questions are still open. In this talk, we will overview some recent advances in this model focusing on the existence, fluctuation and geometry of its geodesics. Based on joint works with M. Damron and J. Hanson. (Received February 16, 2013)

1090-60-85 **Gregory Shinault***, Department of Mathematics, University of Wisconsin-Madison, 480 Lincoln Drive, Madison, WI 53706. *Inhomogeneous Tilings of the Aztec Diamond.*

In this talk we look at random tilings of the Aztec diamond. The tile weights will be determined by their position within the diamond. We will see that the fluctuations of the northern boundary are described by the Tracy-Widom distribution (Received February 19, 2013)

1090-60-124 **Wenjia Liu*** (wjliu@iastate.edu), 12 Physics Hall, Iowa State University, Ames, IA 50014, and **Beate Schmittmann** and **R. K. P. Zia**. *Extraordinary variability and sharp transitions in a maximally frustrated dynamic network*. Preliminary report.

Most previous studies of complex networks have focused on single, static networks. However, in the real world, networks are dynamic and interconnected. Inspired by the presence of extroverts and introverts in the general population, we investigate a highly simplified model of a social network, involving two types of nodes: one preferring the highest degree possible, and one preferring no connections whatsoever. There are only two control parameters in the model: the number of “introvert” and “extrovert” nodes, NI and NE. Our key findings are as follows: As a function of NI and NE, the system exhibits a highly unusual transition, displaying extraordinary fluctuations (as in 2nd order transitions) and discontinuous jumps (characteristic of 1st order transitions). Most remarkably, the system can be described by an Ising-like Hamiltonian with long-range multi-spin interactions and some of its properties can be obtained analytically. This is in stark contrast with other dynamic network models which rely almost exclusively on simulations. (Received February 24, 2013)

1090-60-136 **Nicos Georgiou*** (georgiou@math.utah.edu), 155S, 1400S, Room 233, Salt Lake City, UT 84112, and **Firas Rassoul-Agha**, **Timo Seppalainen** and **Atilla Yilmaz**. *Busemann functions and variational formulas for last passage percolation and polymer models*.

Directed last passage percolation on the two dimensional lattice is exactly solvable when the weight distribution is i.i.d. exponential or geometric. The reason for that is the Burke property associated to a model with “boundaries”.

We investigate the solvable model further in order to generalize the idea of boundaries into the general setting, and we compute a variational formula for passage times for more general weights. The variational formula is given in terms of Busemann functions and has a unique explicit minimizer under some restrictive assumption on the environment.

Versions of the approach will be transferred to polymer models.

Joint work with T. Seppalainen, F. Rassoul-Agha and A. Yilmaz. (Received February 26, 2013)

1090-60-143 **Elizabeth Skubak Wolf*** (skubak@math.wisc.edu) and **David F. Anderson** (anderson@math.wisc.edu). *A Coupled Finite Difference Method for Efficient Computation of Parameter Sensitivities of Discrete Stochastic Biochemical Reaction Networks*.

Parameter sensitivity analysis is a valuable tool in studying discrete stochastic biochemical reaction networks; it is useful, for example, in optimization applications or in experimental design. We present a method for computing first derivatives of the expected values of functions of the state of the system with respect to chosen network parameters. Additionally, we give an extension of this method for the computation of second derivatives. Using the random time change representation and a nontrivial coupling of the perturbed processes in the first or second finite difference, these methods require far fewer paths than other existing methods to achieve an estimator with a desired variance. This drastically lowers the computational complexity required, providing a speed up of at least one order of magnitude over a standard Monte Carlo simulation as well as over the widely used method of common random numbers. Examples and comparisons of performance against other methods will be discussed in the biochemical reaction network setting, though the method is applicable to a wide class of continuous time Markov chain models. (Received February 26, 2013)

1090-60-154 **József Z. Farkas** (jozsef.farkas@stir.ac.uk), Division of Computing Science and Mathematics, University of Stirling, Stirling, FK9 4LA, United Kingdom, **Peter Hinow*** (hinow@uwm.edu), Department of Mathematical Sciences, University of Wisconsin - Milwaukee, P.O. Box 413, Milwaukee, WI 53201, and **Jan Engelstädter** (j.engelstaedter@uq.edu.au), School of Biological Sciences, University of Queensland, Brisbane, QLD 4072, Australia. *Pathogen evolution in switching environments: a hybrid dynamical system approach*.

We propose a hybrid dynamical system approach to model the evolution of a pathogen that experiences different selective pressures according to a stochastic process. In every environment, the evolution of the pathogen is described by a version of the Fisher-Haldane-Wright equation while the switching between environments follows a Markov jump process. We investigate how the qualitative behavior of a simple single-host deterministic system changes when the stochastic switching process is added. In particular, we study the stability in probability of monomorphic equilibria. We prove that in a “constantly” fluctuating environment, the genotype with the highest mean fitness is asymptotically stable in probability while all others are unstable in probability. However, if the probability of host switching depends on the genotype composition of the population, polymorphism can be stably maintained. (Received February 27, 2013)

1090-60-164 **Per Arne Rikvold*** (prikvold@fsu.edu), Department of Physics, Florida State University, Tallahassee, FL 32306-4350, and **Elise Filotas, Lael Parrott** and **Martin Grant**. *Emergence of Spatial Community Structure in Biological Metacommunities*.

The role of space in determining species coexistence and community structure is well established. However, previous studies mainly focus on simple competition and predation systems, and the role of mutualistic interspecies interactions is not well understood. Here we use a spatially explicit metacommunity model, in which new species enter by a mutation process, to study the effect of fitness-dependent dispersal on the structure of communities with interactions comprising mutualism, competition, and exploitation [1,2]. We find that the diversity and interaction network undergo a nonequilibrium phase transition with increasing dispersal rate. Low dispersion rate favors spontaneous emergence of many dissimilar, strongly mutualistic and species-poor local communities. Due to the local dissimilarities, the global diversity is high. High dispersion rate promotes local biodiversity and supports similar, species-rich local communities with a wide range of interactions. The strong similarity between neighboring local communities leads to reduced global diversity.

[1]. E. Filotas, M. Grant, L. Parrott, P.A. Rikvold, J. Theor. Biol. **266**, 419 (2010).

[2]. E. Filotas, M. Grant, L. Parrott, P.A. Rikvold, Ecol. Modell. **221**, 885 (2010). (Received February 27, 2013)

1090-60-175 **Iddo Ben-Ari*** (iddo.ben-ari@uconn.edu), Department of Mathematics, 196 Auditorium Rd, Storrs, CT 06269-3009. *Diffusion with Redistribution*.

We consider a diffusion process on a bounded domain with random redistribution. The redistribution is obtained through either one of the following mechanisms. The first is redistribution when the diffusion hits the boundary, and this is repeated indefinitely. The second is “instantaneous” redistribution, occurring at jump times of some time-changed Poisson process, and the diffusion is killed upon hitting the boundary. By “redistribution” we mean starting the diffusion afresh from some prescribed probability distribution on the domain, which may depend on its location immediately prior to the time the redistribution occurred. For the first, we will focus on ergodicity, spectral gap and coupling. For the second, we will discuss the interplay between the “fast”, continuous diffusion and the “slow”, non-local redistribution process in a “non-elliptic” setting, as it appears through asymptotic behavior of the exit distribution from the domain. (Received February 28, 2013)

1090-60-223 **Yong Han***, 307D Wilhelm Hall, Ames Laboratory - USDOE, Iowa State University, Ames, IA 50011, and **Selena M. Russell, Patricia A. Thiel** and **James W. Evans**. *Fluctuations and 1D decay during coarsening in 2D anisotropic systems*. Preliminary report.

Coarsening of arrays of 2D islands on surfaces is driven by differing 2D equilibrium vapor pressures of islands. Smaller islands with larger edge curvatures have higher vapor pressures and decay by transferring atoms to larger islands. In a 1D system, islands do not have curvature, so atom transfer is a random stochastic process. We describe a 2D system where both surface diffusion and (rectangular) island shapes are strongly anisotropic. Here, there is coarsening with narrower islands exhibiting 1D decay maintaining constant width. Behavior is described by atomistic modeling which accurately captures both the thermodynamics and edge diffusion kinetics of the system. “Atom-tracking” KMC simulations elucidate the transfer of atoms between islands and reveal significant fluctuations in the coarsening process. (Received March 01, 2013)

1090-60-233 **Beate Schmittmann*** (schmittb@iastate.edu), **Jiajia Dong** and **Royce K.P. Zia**. *From asymmetric exclusion processes to protein synthesis*.

Asymmetric exclusion processes, with periodic or open boundaries, have been studied extensively in the mathematics and statistical physics communities, as paradigmatic models for stochastic particle transport far from equilibrium. Though significant progress was made only recently, the original model was actually introduced decades ago to model protein synthesis. In this talk, I will describe recent efforts to develop a comprehensive theory for protein synthesis, building on asymmetric exclusion processes with extended objects, modeling ribosomes covering multiple codons. We discuss the effects of local hopping rates and ribosome size on density profiles and particle currents. The latter translate directly into synthesis rates for the corresponding protein. Some intriguing results for real genes will be presented. (Received March 02, 2013)

1090-60-234 **Jing Wang*** (jingw@iastate.edu), 396 Carver Hall, Department of Mathematics, Ames, IA 50011, and **David Michael Ackerman** and **James W Evans**. *Generalized hydrodynamic treatment of the interplay between single-file diffusion and conversion reaction in nanopores.*

Behavior of conversion reactions (A converts to B) in narrow pores is controlled by a delicate interplay between fluctuations in adsorption-desorption at pore openings, single-file diffusion of A and B, and reaction. This behavior is captured by a generalized hydrodynamic formulation of appropriate reaction-diffusion equations (RDE). These RDE incorporate an unconventional description of chemical diffusion in mixed-component single-file systems based on a refined picture of tracer diffusion for finite-length pores. The RDE elucidate the non-exponential decay of the steady-state reactant concentration into the pore and unusual scaling of the reactant penetration depth.

Reference: Ackerman et al. Phys. Rev. Lett. 108 (2012) 228301. (Received March 02, 2013)

1090-60-244 **Xin Liu*** (liuxin@ima.umn.edu), **Arka Ghosh** and **Amarjit Budhiraja**. *Dynamic Scheduling for Markov Modulated Single-server Multiclass Queueing Systems in Heavy Traffic.*

Queueing networks arise as models in various areas including computer systems, telecommunications, manufacturing, and service industry. One of the key objectives in the queueing network settings is to obtain the “good” (or nearly optimal) control policies for scheduling, sequencing, and routing of jobs in the system. In this talk, I’ll present a recent study on scheduling control problem for a single-server multiclass queueing network in heavy traffic, operating in a changing environment. The changing environment is modeled as a finite state Markov process that modulates the arrival and service rates in the system. Various cases are considered: fast changing environment, fixed environment and slow changing environment. In each of the cases, using weak convergence analysis, in particular functional limit theorems for renewal processes and ergodic Markov processes, it is shown that an appropriate “averaged” version of the classical $c\mu$ -policy (the priority policy that favors classes with higher values of the product of holding cost c and service rate μ) is asymptotically optimal for an infinite horizon discounted cost criterion. (Received March 02, 2013)

1090-60-265 **Rohini Kumar*** (rkumar@math.wayne.edu), **Jin Feng** and **Jean-Pierre Fouque**. *Large deviations in multi-time scale stochastic systems.*

Using the theory of viscosity solutions of partial differential equations, we prove large deviation results for multi-time scale stochastic systems. The talk consists of two parts. In the first part, we look at large deviations in two time scale stochastic systems where the fast and slow processes are diffusions given by coupled SDEs. This problem was motivated from finance when pricing options close to maturity under the assumption of fast mean-reverting stochastic volatility. This was joint work with Jean-Pierre Fouque and Jin Feng. In the second part of the talk, we extend the method developed in the first part, to the case where the fast process is a jump-diffusion process. Due to the jumps in the fast process, the viscosity solutions involved in this case are solutions to partial integro-differential equations. (Received March 03, 2013)

1090-60-303 **David F. Anderson*** (anderson@math.wisc.edu). *Model development and computational methods for biochemical reaction networks with stochastic dynamics.*

I will focus on stochastically modeled cellular processes. The simplest stochastic models of such processes treat the system as a continuous time Markov chain with the state being the number of molecules of each species and with reactions modeled as possible transitions of the chain. I will develop the relevant mathematical representations for the processes and then show how different computational methods can be understood and analyzed by utilizing the stochastic representations. In particular, I will show how to develop a multi-level Monte Carlo estimator which produces unbiased estimates of expectations at a fraction of the cost of usual Monte Carlo methods. Topics discussed will be a subset of: model development, approximation techniques, and variance reduction for Monte Carlo methods. (Received March 04, 2013)

1090-60-307 **Chi-Jen Wang*** (cjwang@iastate.edu), 396 Carver Hall, Ames, IA 50011, and **Da-Jiang Liu** and **James W. Evans**. *Wave and droplet solutions for a spatial epidemic model exhibiting a discontinuous transition to an all-healthy state.*

A population of sick and healthy individual resides on an infinite square lattice. Sick individuals spontaneously recover at rate p , and healthy individual become infected at rate $O(1)$ if they have two or more sick neighbors. As p increases, the model exhibits a discontinuous transition from an infected to an all healthy state. Relative stability of the two states is assessed by exploring the propagation of planar interfaces separating them, although we find that equistability depends on orientation of the interface. We also explore the evolution of droplet-like

configurations (e.g., an infected region embedded in an all healthy state). We analyze this stochastic model by applying truncation approximations to the exact master equations describing the evolution of non-uniform states. We thereby obtain a set of discrete (or lattice) reaction-diffusion equations amenable to numerical analysis. (Received March 04, 2013)

1090-60-314 **Da-Jiang Liu*** (dajiang@fi.ameslab.gov), Ames, IA 50011, and **Chi-Jen Wang** (cjwang@iastate.edu) and **J. W. Evans** (evans@ameslab.gov). *Nonequilibrium First-Order Transition in the Quadratic Contact Process or Schloegl's second Model.*

First-order transitions in nonequilibrium systems are fundamentally different from their equilibrium counterparts through the generic nature of the phase coexistence, i.e., instead of a single point in the one-parameter phase space, two-phase coexistence (2PC) occurs over a range of parameters. We choose the quadratic contact process, or the equivalent lattice implementation of Schloegl's second model for autocatalysis as the prototype. While many aspects of the transitions can be studied and understood through the use of discrete reaction-diffusion equations, stochastic effects also qualitatively change of behavior. Such stochastic effects are most fruitfully studied through Monte Carlo simulations, in particular, the constant population (coverage) algorithm is developed to study the interfaces of 2PC. Effects of dimensionality are studied in details. (Received March 04, 2013)

1090-60-325 **Arka P Ghosh*** (apghosh@iastate.edu), 3216 Snedecor Hall, Iowa State University, Iowa State University, Ames, IA 50011-1210. *Optimal rate for a queueing system in heavy traffic with superimposed On-Off arrivals.*

We consider a queueing control problem for a system with heavy-tailed On-Off process arrivals and constant-rate service (control). The control problem is to find the optimal value of the service rate which minimizes an infinite horizon discounted cost function. The main result of the paper guarantees the existence of an optimal rate as well as specifies an explicit range of possible values of this optimal rate. As a part of the analysis, we also formulated and solved an approximating control problem driven by fractional Brownian motion. A key ingredient of the proof (and a result of independent interest) is an asymptotic maximal bound on the second moment of the centered cumulative On-Off process, which is also derived. (Received March 04, 2013)

1090-60-331 **Sebastien Roch*** (roch@wisc.edu). *Assembling the tree of life: theory beyond the substitution-only model of sequence evolution.*

Recent advances in DNA sequencing technology have led to new mathematical challenges in the analysis of the massive datasets produced in current evolutionary studies. In particular, much progress has been made in the design and analysis of computationally efficient algorithms for assembling the Tree of Life from present-day molecular sequences. In the first half of the talk, I will briefly review some of the mathematical techniques that have led to our current understanding of large-scale tree-building algorithms. Prior theoretical results, however, often rely on statistical models of molecular evolution that are too simplistic. In the second half, I will discuss recent work on the probabilistic modeling and analysis of more complex settings, including insertion-deletion events and lateral genetic transfer. No biology background will be assumed. (Received March 04, 2013)

1090-60-339 **Jasmine Foo*** (jyfoo@umn.edu), 206 Church St SE, University of Minnesota, School of Mathematics, Minnesota, MN 55455. *Accumulation and spread of mutations in a spatially structured population.*

I will discuss a stochastic model (based on biased voter dynamics) of mutation accumulation and spread in a spatially-structured population. This situation arises in a variety of ecological and biological problems, including the process of cancer initiation from healthy tissue. We investigate the temporal dynamics and spatial patterns of mutation accumulation, and how they depend on system parameters such as mutation rate, population size, and selective fitness advantage of mutations. This study will be facilitated by building a mesoscopic model based on our underlying particle system model of the population. This is joint work with R. Durrett and K. Leder. (Received March 04, 2013)

1090-60-358 **Jose E Figueroa-Lopez*** (figueroa@stat.purdue.edu), 250 N. University Street, West Lafayette, IN 47907, and **Peter Tankov** (tankov@math.univ-paris-diderot.fr), Site Chevaleret, 75205 Paris, France. *Small-time asymptotics of stopped Lévy bridges and simulation schemes with controlled bias.* Preliminary report.

We characterize the small-time asymptotic behavior of the exit probability of a Lévy process out of a two-sided interval and of the law of its overshoot, conditionally on the terminal value of the process. The asymptotic expansions are given in the form of a first order term and a precise computable error bound. As an application of these formulas, we develop a novel adaptive discretization scheme for the Monte Carlo computation of functionals of killed Lévy processes with controlled bias. The considered functionals appear in several domains of

mathematical finance, including barrier options, structural credit risk models, and contingent convertible bonds. (Received March 04, 2013)

65 ► Numerical analysis

1090-65-22 **Nguyen Hoang*** (nhoang@math.ou.edu), The University of Oklahoma, Department of Mathematics, Norman, OK 73019. *ON NODE DISTRIBUTIONS FOR INTERPOLATION AND SPECTRAL METHODS.*

A scaled Chebyshev node distribution is studied in this paper. It is proved that the node distribution is optimal for interpolation in $C\{-\}M^{s+1}[-1, 1]$, the set of $(s+1)$ -time differentiable functions whose $(s+1)$ -th derivatives are bounded by a constant $M > 0$. Node distributions for computing spectral differentiation matrices are proposed and studied. Numerical experiments show that the proposed node distributions yield results with higher accuracy than the most commonly used Chebyshev-Gauss-Lobatto node distribution. (Received January 10, 2013)

1090-65-57 **Juhi Jang** (juhi.jang@ucr.edu), Math Department, UC Riverside, Riverside, CA 92521, **Fengyan Li** (lif@rpi.edu), Math Department, RPI, Troy, NY 12180, **Jingmei Qiu*** (jingqiu@math.uh.edu), Math Department, University of Houston, Houston, TX 77002, and **Tao Xiong** (xiongt001@gmail.com), Math Department, University of Houston, Houston, TX 77002. *High-order asymptotic preserving discontinuous Galerkin schemes to discrete-velocity kinetic equations in a diffusive regime.*

In this paper, we develop a family of high-order asymptotic preserving (AP) schemes to discrete-velocity kinetic equations in a diffusive regime that lead to diffusive macroscopic models such as the heat equation, the porous media equation, the advection-diffusion equation, and the viscous Burgers' equation in the asymptotic limit. Our approach is based on the so-called micro-macro formulation of the kinetic equation which involves the natural decomposition of the kinetic equation to the equilibrium part and non-equilibrium part. The new ingredients of our numerical work to achieve the higher-order accuracy are the following: we introduce discontinuous Galerkin (DG) methods in space variable based on one set of computational grid; we employ high order globally stiffly accurate implicit-explicit (IMEX) scheme for time discretization. As a result, we have a family of uniformly stable, asymptotically preserving schemes with uniform high order spatial accuracy. In this paper, we also establish the stability and error analysis of the proposed high order DG scheme with first order IMEX temporal discretization. Numerical results demonstrating the effectiveness, high order accuracy and efficiency of proposed high order schemes are presented. (Received February 07, 2013)

1090-65-122 **Yekaterina Epshteyn*** (epshteyn@math.utah.edu), Yekaterina Epshteyn, Department of Mathematics, Salt Lake City, UT 84112. *Numerical methods for chemotaxis models.*

In this talk, I will first discuss several chemotaxis models including the classical Patlak-Keller-Segel (PKS) model. Chemotaxis is the phenomenon in which cells, bacteria, and other single-cell or multicellular organisms direct their movements according to certain chemicals (chemoattractants) in their environment. The mathematical models of chemotaxis are usually described by highly nonlinear time dependent systems of PDEs. Therefore, accurate and efficient numerical methods are very important for the validation and analysis of these systems. Furthermore, a common property of all existing chemotaxis systems is their ability to model a concentration phenomenon that mathematically results in solutions rapidly growing in small neighborhoods of concentration points/curves. The solutions may blow up or may exhibit a very singular, spiky behavior. In either case, capturing such solutions numerically is a challenging problem. In the talk we will discuss and compare recently developed numerical methods for the (PKS) chemotaxis model. Numerical experiments to demonstrate the stability and accuracy of the proposed methods for chemotaxis models will be presented. Ongoing research projects will be discussed as well. (Received February 24, 2013)

1090-65-126 **Jangwoon (Leo) Lee*** (llee3@umw.edu), Department of Mathematics, University of Mary Washington, 1301 College Avenue, Fredericksburg, VA 22401, and **Hyung-Chun Lee.** *Discretization of Stochastic Optimal Control Problems by the $h \times p$ Version of the Stochastic Galerkin FEM.*

We analyze the $h \times p$ version of the stochastic Galerkin finite element method for an optimal control problem constrained by stochastic elliptic problems. The main result is that the $h \times p$ version leads to an exponential rate of convergence with respect to p . We extends the results for stochastic elliptic problems into optimal control problems subject to stochastic elliptic problems. Numerical examples are used to confirm the theoretical results. (Received February 25, 2013)

- 1090-65-133 **Jue Yan*** (jyan@iastate.edu), 484 Carver Hall, Iowa State University, Ames, IA 50010. *Maximum-principle-satisfying high order Direct discontinuous Galerkin method for convection diffusion equations.*

The discontinuous Galerkin (DG) method is a class of finite element method that use completely discontinuous piecewise function space for the numerical solution and the test function. Without the continuity restriction, DG methods have the flexibility which is not shared by classical finite element methods.

In this talk, I will discuss our recent studies on the Direct Discontinuous Galerkin(DDG) methods for convection diffusion equations. We will show the DDG method and its variations all satisfy the strict maximum principle with quadratic polynomial approximations. Sufficient conditions are given to guarantee the polynomial solutions bounded above and below by the given constants. Extension to two-dimensional rectangular meshes and triangular meshes will be discussed. Numerical examples will be presented to verify the optimal 3rd order of accuracy is maintained with the maximum principle limiter. The positivity of the polynomial solutions are maintained sharply for nonlinear porous medium equations. (Received February 25, 2013)

- 1090-65-135 **Gerard Awanou*** (awanou@uic.edu), Chicago, IL 60607. *Pseudo transient continuation and time marching methods for Monge-Ampère type equations.*

We present two numerical methods for the fully nonlinear elliptic Monge-Ampère equation. The first is a pseudo transient continuation method and the second is a pure pseudo time marching method. The methods are proved to converge for smooth solutions. We give numerical evidence that they are also able to capture the viscosity solution of the Monge-Ampère equation. Even in the case of the degenerate Monge-Ampère equation, the time marching method appears also to compute the viscosity solution. (Received March 05, 2013)

- 1090-65-139 **Weimin Han*** (weimin-han@uiowa.edu), Department of Mathematics & AMCS, University of Iowa, Iowa City, IA 52241. *A Splitting Method for Differential Approximations of the Radiative Transport Equation.*

The radiative transport equation (RTE) arises in a variety range of applications in sciences and engineering. It is challenging to solve RTE numerically due to its integro-differential form, high dimension, and numerical singularity of the integral kernel function for applications in highly forward-peaked media. For this reason, various approximations of RTE have been proposed in the literature. This talk discusses a family of differential approximations (RT/DAEs) of the RTE and proposes a convergent splitting method for RT/DAEs. (Received February 26, 2013)

- 1090-65-159 **Michael J. Neilan*** (neilan@pitt.edu), University of Pittsburgh, Department of Mathematics, 301 Thackeray Hall, Pittsburgh, PA 15260. *Finite element methods for the fully nonlinear Monge-Ampère equation.*

In this talk I will discuss finite element methods for the fully nonlinear Monge-Ampère equation. The main feature of our discretizations is that their linearizations are coercive over the finite element space. I will describe a simple procedure to construct such schemes and briefly discuss the difficulties in the convergence analysis. Finally, numerical examples for a series of benchmark problems will be presented. (Received February 27, 2013)

- 1090-65-169 **Eitan Tadmor*** (tadmor@cscamm.umd.edu), Center for Scientific Comput.& Math. Modeling, CSCAMM, CSIC Bldg. #406, Paint Branch Drive, College Park, MD 20742. *No artificial numerical viscosity: from the 1/3 rule to entropy stable approximations of Navier-Stokes and related equations.*

Entropy stability plays an important role in the dynamics of nonlinear systems of conservation laws and related convection-diffusion equations. What about the corresponding numerical framework? we present a general theory of entropy stability for difference approximations of such nonlinear equations. Our approach is based on comparing numerical viscosities to certain entropy conservative schemes. It yields precise characterizations of entropy stability which is enforced in rarefactions while keeping sharp resolution of shocks.

We demonstrate this approach with a host of first- and second-order accurate schemes ranging from scalar examples to Euler and Navier-Stokes equations. In particular, we present a family of energy-stable schemes for the shallow-water equations, with a well-balanced description of moving equilibria states. Numerical experiments provide a remarkable evidence for the different roles of viscosity and heat conduction in forming sharp monotone profiles in the immediate neighborhoods of shocks and contacts. (Received February 27, 2013)

1090-65-202 **Xiaobing H. Feng*** (xfeng@math.utk.edu), Department of Mathematics, The University of Tennessee, Knoxville, TN 37996. *Finite Element Method for Poroelasticity Models of Soft Matters and Soil Mechanics.*

In this talk I shall present a multiphysics finite element method for a poroelasticity model and for its limiting model (as the constrained storage coefficient tends to zero) which is known as Biot's consolidation problem in soil mechanics and is also known as Doi's model for polymer gels. The main idea of our approach is to derive a multiphysics reformulation of the poroelasticity model by introducing an "elastic pressure" and showing that such a pressure is governed by a diffusion process. Based on this new formulation we then propose a novel fully discrete finite element method for approximating the model. At each time step the proposed multiphysics finite element method consists of solving two sub-problems: one of which is a generalized Stokes-type problem for the displacement vector field (of the elastic body) and another is a diffusion problem for a "pseudo-pressure" field (of the solvent in the pores). Error estimate and numerical experiment results will be presented to demonstrate the accuracy and efficiency of the proposed method. This is a joint work with Yinnian He of Xian Jiaotong University and Zhihao Ge of Henan University in China. (Received March 01, 2013)

1090-65-203 **Xiaobing H. Feng*** (xfeng@math.utk.edu), Department of Mathematics, The University of Tennessee, Knoxville, TN 37996. *Nonstandard Discontinuous Galerkin Methods for Fully Nonlinear Second Order PDEs.*

In this talk I shall present some latest advances on developing discontinuous Galerkin (DG) methods for fully nonlinear second order PDEs such as the Monge-Ampere type equations and Hamilton-Jacobi-Bellman equations. The focus of the talk is to discuss a new and general strategy for constructing such DG methods which can reliably approximate viscosity solutions of the fully nonlinear PDEs. The proposed DG methods are high order and triangular mesh generalizations of a new class of finite difference methods developed by the author and collaborators for these fully nonlinear second order PDEs. Numerical experiment results will also be presented to show the performance of the proposed DG methods. This is a joint work with Thomas Lewis of the University of Tennessee at Knoxville. (Received March 01, 2013)

1090-65-205 **Weizhang Huang*** (huang@math.ku.edu), Department of Mathematics, University of Kansas, 1460 Jayhawk Boulevard, Room 405, Lawrence, KS 66049, and **Lennard Kamenski**. *How a nonconvergent recovered Hessian works in mesh adaptation.*

Hessian recovery has been commonly used in mesh adaptation for obtaining the required magnitude and direction information of the solution error. Unfortunately, a recovered Hessian from a linear finite element approximation is nonconvergent in general as the mesh is refined. It has been observed numerically that adaptive meshes based on such a nonconvergent recovered Hessian can nevertheless lead to an optimal error in the finite element approximation. This also explains why Hessian recovery is still widely used despite its nonconvergence. In this talk I will present an error bound for the linear finite element solution of a general boundary value problem. The bound is valid under a mild assumption on the closeness of the recovered Hessian to the exact one. Numerical results show that this closeness assumption is satisfied by the recovered Hessian obtained with commonly used Hessian recovery methods. Moreover, it is shown that the finite element error changes gradually with the closeness of the recovered Hessian. This provides an explanation on how a nonconvergent recovered Hessian works in mesh adaptation. (Received March 01, 2013)

1090-65-238 **James Rossmannith*** (rossmani@iastate.edu), Iowa State University, Department of Mathematics, 396 Carver Hall, Ames, IA 50011. *Discontinuous Galerkin Constrained Transport Schemes for Ideal Magnetohydrodynamics in Multiple Dimensions.*

The modification of the celebrated Yee scheme from the vacuum Maxwell equations to magnetohydrodynamics (MHD) is often referred to as the constrained transport (CT) approach. CT can be viewed as a predictor-corrector method for updating the magnetic field, where a magnetic field value is first predicted by a method that does not exactly preserve the divergence-free condition on the magnetic field, followed by a correction step that aims to control these divergence errors. This strategy has been successfully used in conjunction with a variety of shock-capturing methods including WENO (weighted essentially non-oscillatory), central, and wave propagation schemes. In this work we show how to extend the basic CT framework in the context of the discontinuous Galerkin (DG) finite element method on both 2D and 3D Cartesian grids. We first review the entropy-stability theory for semi-discrete DG discretizations of ideal MHD, which rigorously establishes the need for both local and global divergence-free finite element representations of the magnetic field. Next we introduce a constrained transport scheme that is based on achieving a globally divergence-free magnetic field via the use of a magnetic potential. The resulting methods are validated on several standard test cases. (Received March 02, 2013)

1090-65-251 **S. Zhou, Z. Wang*** (zwang6@fiu.edu) and **B. Li**. *Mean-Field Description of Ionic Size Effects with Non-Uniform Ionic Sizes: A Numerical Approach.*

Ionic size effects are significant in many biological systems. Mean-field descriptions can be efficient but also challenging. When ionic sizes are different, explicit formulas are not available. This work begins with a variational formulation of electrostatics of an ionic solution with such non-uniform ionic sizes as well as multiple ionic valences. An augmented Lagrange multiplier method is then developed and implemented to numerically solve the constrained optimization problem. The method is shown to be accurate and efficient, and is applied to ionic systems with non-uniform ionic sizes. Extensive numerical tests demonstrate that the mean-field model and numerical method capture qualitatively some significant ionic size effects, particularly those for multivalent ionic solutions, such as the stratification of multivalent counterions near a charged surface. The ionic valence-to-volume ratio is found to be the key physical parameter in the stratification of concentrations. All these are not well described by the classical Poisson–Boltzmann theory, or the generalized Poisson–Boltzmann theory that treats uniform ionic sizes. Finally, various issues such as the close packing, limitation of the continuum model, and generalization of this work to molecular solvation are discussed. (Received March 03, 2013)

1090-65-264 **Zhiliang Xu, Xu-Yan Chen** and **Yingjie Liu*** (yingjie@math.gatech.edu). *A New Runge-Kutta Discontinuous Galerkin Method with Conservation Constraints to Improve CFL Condition for Solving Conservation Laws.* Preliminary report.

We present a new formulation of the Runge-Kutta discontinuous Galerkin (RKDG) method for conservation Laws. The new formulation requires the computed RKDG solution in a cell to satisfy additional conservation constraint in adjacent cells and does not increase the complexity or change the compactness of the RKDG method. This new formulation improves the CFL number even further over the first version presented in Xu et al, JCP 2011. (Received March 03, 2013)

1090-65-282 **Braxton Osting** and **Chiu-Yen Kao*** (ckao@cmc.edu), 850 Columbia Ave, Claremont, CA 91711. *Geometric optimization of Dirichlet-Laplacian eigenvalues.*

In this talk, the geometric optimization problem where the objective function depends on Laplace-Dirichlet eigenvalues is presented. The domains which minimize the first few single Laplace-Dirichlet eigenvalues are known analytically and/or have been studied computationally and it is known that the optimal solution for the second eigenvalue have multiply connected components. Our computations based on the level set approach and the gradient decent method reproduce these previous results and extend these results to convex combination of sequential eigenvalue problems, effectively capturing intermediate shape and topology changes. Several properties of minimizers are studied computationally, including uniqueness, connectivity, symmetry, and eigenvalue multiplicity. (Received March 04, 2013)

1090-65-296 **Leopold Matamba Messi***, Mathematical Biosciences Institute, The Ohio State University, Columbus, OH 43210, and **Ming-jun Lai** (mj1lai@math.uga.edu), Department of Mathematics, The University of Georgia, Athens, GA 30602. *A Finite Elements Method for Total Variation Minimization.*

In total variation denoising, one attempts to enhance an image by solving a constrained minimization problem with a total variation objective. More recently, Caselles et al. have shown that the total variation model proposed by Rudin, Osher and Fatemi (ROF) is capable of preserving some regularity of the data. In this talk, I will present a continuous piecewise linear approximation of the ROF model that converges when the data are bonded and weakly regular in the sense of $Lip(\alpha, L^2(\Omega))$, and Ω is a rectangular domain. (Received March 04, 2013)

1090-65-302 **Sheng Zhang*** (szhang@wayne.edu). *Compact embedding in the space of piecewise H^1 functions.*

We prove a compact embedding theorem in a class of spaces of piecewise H^1 functions subordinated to a class of shape regular, but not necessarily quasi-uniform triangulations of a polygonal domain. This result generalizes the Rellich–Kondrachov theorem. It is used to prove generalizations to piecewise functions of nonstandard Poincaré–Friedrichs inequalities. It can be used to prove Korn inequalities for piecewise functions associated with elastic shells. (Received March 04, 2013)

1090-65-313 **Michael Pollack***, 2505 Jensen Ave Unit 416, Ames, IA 50010. *Alternating Evolution Discontinuous Galerkin methods for Hamilton-Jacobi Equations.*

In this work, we propose a high resolution Alternating Evolution (AE) discontinuous Galerkin method to solve Hamilton-Jacobi equations. The construction of the AEDG is based on an alternating evolution system of the Hamilton-Jacobi equation, following the idea previously developed for hyperbolic conservation laws. A semi-discrete AEDG derives directly from a sampling of this system on alternating cells. Higher order accuracy

is achieved by a combination of high-order non-oscillatory polynomial approximation in each cell and a time discretization with matching accuracy. The AEDG methods have the advantage of easy formulation and implementation, and efficient computation of the solution. For the linear equation, we prove the L^2 stability of the method. Numerical experiments for a set of Hamilton-Jacobi equations are presented to demonstrate both accuracy and capacity of these AEDG schemes. (Received March 04, 2013)

1090-65-342 **Songting Luo*** (luos@iastate.edu). *Resolution of source singularities for the point-source eikonal equations with systematic factorization approach.*

The solution for the eikonal equation with a point-source condition has an upwind singularity at the source point so that all formally high-order numerical schemes for the eikonal equation yield first-order convergence and relatively large errors. We propose a systematic approach to resolving the source singularities by factorizing the eikonal into two multiplicative or additive factors, one of which is specified to approximate the eikonal up to arbitrary order of accuracy near the source, and the other of which serves as a higher-order correction term. With such decompositions, high order schemes are designed to compute the correction terms with high order accuracy, hence the eikonal can be recovered with high order accuracy. Two- and three-dimensional numerical examples demonstrate that a hybrid p-th order fast sweeping method yields desired, uniform, clean p-th order convergence in a global domain by using a p-th order factorization. (joint with R. Burrige and J. Qian) (Received March 04, 2013)

1090-65-357 **Hailiang Liu*** (hliu@iastate.edu), Iowa State University, Carver 434, Ames, IA 50011. *Direct Discontinuous Galerkin Methods for Dispersive Integrable Equations.*

In this talk, I shall discuss the recent development of direct discontinuous Galerkin methods for solving dispersive integrable equations, including both the KdV equation and the Degasperis-Procesi equation. The DP equation is integrable, but admits possibly discontinuous solutions, and therefore suitable for modeling both short wave breaking and long wave propagation phenomena. The proposed DG method is high order accurate, and preserves two invariants, momentum and energy, of this nonlinear equation, hence producing wave solutions with satisfying long time behavior. The L^2 -stability of the scheme for general solutions is a consequence of the energy preserving property. The numerical simulation results for different types of solutions of the nonlinear Degasperis-Procesi equation are provided to illustrate the accuracy and capability of the method. This is a joint work with Yunqing Huang and Nianyu Yi. (Received March 04, 2013)

1090-65-401 **Nicolae Tarfulea*** (tarfulea@purduecal.edu), Purdue University Calumet, Department of Mathematics, 2200 169th Street, Hammond, IN 46323. *Generalized Finite Element Method for Elliptic Equations with Essential Boundary Conditions.*

One of the major problems in the implementation of the Generalized Finite Element Method is the enforcement of essential boundary conditions. In this talk we address this topic in the case of boundary value problems involving second-order elliptic operators. (Received March 05, 2013)

1090-65-405 **Yingda Cheng*** (ycheng@math.msu.edu), East Lansing, MI 48824, and **Andrew Christlieb** and **Xinghui Zhong**. *Energy conserving schemes for Vlasov-Ampere and Vlasov-Maxwell system.* Preliminary report.

In this talk, we will introduce energy conserving schemes for Vlasov Ampere and Vlasov Maxwell systems. The proposed methods preserve the total energy of the system, and they have a systematic framework to incorporate explicit and implicit temporal discretizations. The discontinuous Galerkin methods with suitable numerical fluxes are used to guarantee such properties. (Received March 05, 2013)

1090-65-418 **Jian-Feng Cai*** (jianfeng-cai@uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52242, and **Sibin Huang**, **Hui Ji**, **Zuwei Shen** and **Gui-Bo Ye**. *Data-driven tight frame construction and image denoising.* Preliminary report.

The regularization methods for image restoration using the L^1 norm of the coefficients of the underlying image under some system assume that the image has a good sparse approximation under the given system. Such a system can be a basis, a frame or a general over-complete dictionary. One widely used system in image restoration is wavelet tight frame. There have been enduring efforts on seeking wavelet type of tight frames under which certain class of functions or images can have a good sparse approximation. However, the structure of images varies greatly in practice and a system working well for one type of images may not work for another. This talk presents a method that derives discrete tight frame system from the input image itself to provide a better sparse approximation to the input image. Such an adaptive tight frame construction scheme is applied on image denoising by constructing a tight frame tailor down to the given noisy data. The experiments showed the proposed approach performs better in image denoising than those wavelet tight frames designed for a class of

images. Moreover, by ensuring the system derived from our approach is always a tight frame, our approach also runs much faster than some other adaptive dictionary based approaches with comparable PSNR performance. (Received March 05, 2013)

1090-65-433 **David C Seal*** (seal@math.msu.edu), 619 Red Cedar Road, East Lansing, MI 48824, and **Yaman Guclu** and **Andrew Christlieb**. *High-order multidervative integrators for hyperbolic conservation laws.*

Multiderivative integrators have a long history of development dating back to the 1950's, yet to date, they are still waiting to see their full potential for the numerical solution of partial differential equations. In this work, we propose the application of explicit high-order multidervative integrators for solving hyperbolic conservation laws. One of the primary considerations towards developing numerical schemes devoted to scientific computing lies within a recognition of modern day architecture. Given their low storage footprint, multidervative integrators make for a competitive advantage when compared with their high-order Runge-Kutta counterparts. The primary advantage of their use is twofold: multidervative integrators require a low memory footprint, which is advantageous on modern day architecture such as general-purpose graphics processing units (GPGPUs); second, multidervative integrators require less work in terms of number of Riemann solves and number of WENO reconstructions when inserted into modern high-order technology for solving hyperbolic conservation laws. (Received March 06, 2013)

68 ► Computer science

1090-68-171 **Elvira Mayordomo*** (elvira@unizar.es), DIIS, EINA, Univ. Zaragoza, Maria de Luna 1, 50018 Zaragoza, Spain. *Effective dimension in general metric spaces.*

We introduce the concept of effective dimension for a wide class of metric spaces. Effective dimension was defined by Lutz in (Lutz 2003) for Cantor space and has also been extended to Euclidean space. Our extension to other metric spaces is based on a supergale characterization of Hausdorff dimension. We present here the concept of constructive dimension and its characterization in terms of Kolmogorov complexity. We also explore the relationship with computable metric spaces. Further research directions are indicated. (Received February 28, 2013)

1090-68-345 **Adam Case***, Department of Computer Science, Iowa State University, Ames, IA 50011, and **Jack H. Lutz**, Department of Computer Science, Iowa State University, Ames, IA 50011. *Mutual Dimension.*

We define the *mutual dimension* $mdim(x : y)$ between any two points x and y in Euclidean space. Intuitively this is the density of the algorithmic information shared by x and y . We show that this quantity satisfies the main desiderata for a satisfactory measure of mutual algorithmic information. Our main theorem, the *data processing inequality* for mutual dimension, says that, if $f : \mathbb{R}^m \rightarrow \mathbb{R}^n$ is computable and Lipschitz, then the inequality $mdim(f(x) : y) \leq mdim(x : y)$ holds for all $x \in \mathbb{R}^m$ and $y \in \mathbb{R}^n$. We use this inequality and related inequalities that we prove in like fashion to establish conditions under which various classes of computable functions on Euclidean space preserve or otherwise transform mutual dimension between points. (Received March 04, 2013)

1090-68-370 **Eric Allender*** (allender@cs.rutgers.edu), Department of Computer Science, Rutgers University, Hill Center, 110 Frelinghuysen Road, Piscataway, NJ 08854-8019. *Strengthening the Link between Complexity Classes and Kolmogorov Complexity.* Preliminary report.

This talk centers around some audacious conjectures that attempt to forge firm links between computational complexity classes and the study of Kolmogorov complexity.

More specifically, let R denote the set of Kolmogorov-random strings. Two familiar complexity classes are:

- BPP: the class of problems that can be solved with negligible error in polynomial-time, and
- NEXP: the class of problems solvable in nondeterministic exponential time.

Conjecture 1: $NEXP = NP^R$.

Conjecture 2: BPP is the class of problems non-adaptively polynomial-time reducible to R .

The first thing to note is that these conjectures are not only audacious; they are obviously false! R is not a decidable set, and thus it is absurd to suggest that the class of problems reducible to it constitutes a complexity class.

The absurdity fades if, for example, we interpret “ NP^R ” to be “the class of problems that are NP-Turing reducible to R , no matter which universal machine we use in defining Kolmogorov complexity”. The lecture will

survey the body of work that suggests that, when interpreted properly, the conjectures may actually be true. (Received March 04, 2013)

1090-68-375 **Jin-Yi Cai*** (jyc@cs.wisc.edu). *Complexity dichotomy theorems for counting problems.*

I will give a report on some significant progress in the study of the exact complexity of counting problems. Specifically I will describe the classification program of counting complexity of locally specified problems. This classification program is advanced in three interrelated frameworks: Graph Homomorphisms, Counting CSP, and Holant Problems.

In each formulation, complexity dichotomy theorems have been achieved which classify every problem in a given class to be either solvable in polynomial time or $\#P$ -hard. The proof techniques are mainly algebraic and combinatorial.

This is in marked contrast to the situation in recursion theory, where Emil Post initiated the investigation regarding the existence of r.e. Turing degrees between 0 and 0'. The famous solution came independently from Friedberg and Muchnik, who invented the finite injury priority argument, and recursion theory has blossomed into a formidable mathematical discipline after that. However, these dichotomy theorems provide a different picture at the P vs. NP and $\#P$ level. It is an interesting question whether there are similar interesting subclasses of the decidability theory where this type of dichotomy classification theorems can be proved. (Received March 05, 2013)

1090-68-382 **Andrew Hughes, A Pavan*** (pavan@cs.iastate.edu), **Nathan Russell** and **Alan Selman**. *A Thirty Year Old Conjecture about Promise Problems.*

Even, Selman, and Yacobi formulated a conjecture that asserts that there do not exist disjoint NP-pairs all of whose separators are NP-hard via Turing reductions. In this this work we consider a variant of this conjecture—there do not exist disjoint NP-pairs all of whose separators are NP-hard via bounded truth-table reductions, and provide evidence for this conjecture. (Received March 05, 2013)

1090-68-385 **Nicholas Mattei, Judy Goldsmith*** (goldsmi@cs.uky.edu), **Andrew Klapper** and **Martin Mundhenk**. *On the Complexity of Bribery and Manipulation in Tournaments with Uncertain Information.*

We study the computational complexity of bribery and manipulation schemes for sports tournaments with uncertain information. We introduce a general probabilistic model for multi-round tournaments. We also consider several special types of tournament: challenge (or caterpillar), cup, and round robin. Our results carry over to the equivalent voting rules: sequential pair-wise elections, cup, and Copeland, when the set of candidates is exactly the set of voters. This restriction, that candidates equal voters, creates new difficulties for most existing manipulation algorithms. The complexity of bribery and manipulation are well studied, almost always assuming deterministic information about votes and results. We assume that for candidates i and j the probability that i beats j and the costs of lowering each probability by fixed increments are known to the manipulators. We provide complexity analyses for several problems related to manipulation and bribery for the various types of tournaments. Complexities range from probabilistic log space to np^{PP} . This shows that the introduction of uncertainty into the reasoning process drastically increases the complexity of bribery problems in some instances. (Received March 05, 2013)

1090-68-394 **Vinodchandran N Variyam*** (vinod@cse.unl.edu), Department of Computer Science, University of Nebraska-Lincoln, Lincoln, NE. *On the Space Complexity of the Graph Reachability Problem.*

The graph reachability problem, the computational problem of deciding whether there is a path between two given vertices in a graph, is the canonical problem while studying computations with limited memory. Different variations of this problem characterize various important space bounded computations. Understanding the complexity of the reachability problem is a central concern of computational complexity theory.

In this talk I will present some recent progress we have made on certain central open questions on the complexity of the reachability problem. (Received March 05, 2013)

1090-68-414 **John M. Hitchcock*** (jhitchco@cs.uwyo.edu), Department of Computer Science, University of Wyoming, Laramie, WY, and **Joshua C. Sanderlin** (jsande18@uwyo.edu), Department of Computer Science, University of Wyoming, Laramie, WY. *Polynomial-Time Randomness and Differentiability.*

A recent line of research has shown tight connections between algorithmic randomness and computable analysis. For example, Brattka, Miller, and Nies proved that a real number is computably random if and only if every computable nondecreasing function is differentiable at that point.

We extend this effectivization of the Lebesgue differentiation theorem to the level of computational complexity, in particular proving a polynomial-time version. There are a number of considerations that arise in formulating the result, designing the algorithms in its proof, and giving the analysis that do not appear in the setting of computability theory. (Received March 05, 2013)

1090-68-429 **Eric Schost*** (eschost@uwo.ca). *Lifting techniques for polynomial systems.*

I will explain how symbolic homotopy techniques, possibly combined with algorithms for structured linear systems, can be used in order to solve systems of questions coming from e.g. the computation of torsion divisors on Jacobians of curves. (Received March 05, 2013)

70 ► *Mechanics of particles and systems*

1090-70-4 **Eitan Tadmor*** (tadmor@cscam.umd.edu), Center for Scientific Comput.& Math. Modeling, CSCAMM, CSIC Bldg #406, Paint Branch Drive, College Park, MD 20742, and **Sebastien Motsch** and **Changhui Tan**. *Consensus and Flocking in Self-organizer dynamics.*

We discuss self-organized dynamics of agent-based models with focus on a prototype model driven by non-symmetric self-alignment introduced in [1]. Unconditional consensus and flocking emerge when the self-alignment is driven by global interactions with a sufficiently slow decay rate. In more realistic models, however, the interaction of self-alignment is compactly supported, and then questions arise regarding the emergence of clusters/flocks/consensus, which are related to the propagation of connectivity of the underlying graph. In particular, we discuss heterophilous self-alignment: here, the pairwise interaction between agents increases with the diversity of their positions and we assert that this diversity enhances flocking/consensus. The methodology carries over from agent-based to kinetic and hydrodynamic descriptions.

[1] A new model for self-organized dynamics and its flocking behavior, J. Stat.Physics 144(5) (2011) 923-947. (Received March 18, 2012)

1090-70-273 **G Iyer**, **N Leger** and **R L Pego*** (rpego@cmu.edu), Dept. Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213. *Dynamic scaling for kinetic clustering models that govern critical branching processes.*

Smoluchowski's coagulation equation is a simple kinetic model for clustering whose scaling dynamics relates to limit theorems in probability in remarkable ways. Such a model governs the merging of ancestral trees in critical branching processes, as recent work of Bertoin and Le Gall has indicated. We plan to discuss work which establishes necessary and sufficient conditions for the asymptotic self-similarity of clan size distributions in critical branching processes, based on a renormalization-group analysis of the coagulation dynamics. (Received March 03, 2013)

74 ► *Mechanics of deformable solids*

1090-74-94 **Peter Smereka*** (psmereka@umich.edu), 530 Church St., Ann Arbor, MI 48109, and **Arvind Baskaran** and **Christian Ratsch**. *Inability of Continuum Theory to Evaluate the Elastic Energy of Alloys.*

It is demonstrated that a widely used continuum model for elasticity in alloys fails in the determination of the elastic energy. We show that the elastic energy in a finely mixed alloy system is larger than the elastic energy in a segregated system. This means that misfit strain drives segregation and spinodal decomposition, whereas continuum theory predicts the opposite. Continuum theory fails because it does not take atomistic scale compositional nonuniformity into account. Our work implies that it is critical to include the microscopic arrangements in any elastic model to achieve even qualitatively correct behavior. The results are based on the analysis of a ball and spring model of a binary alloy system and are confirmed by density-functional theory calculations for the Si/Ge and Ag/Pt systems. (Received February 20, 2013)

1090-74-221 **Shuwang Li*** (sli@math.iit.edu), Engineering one Bldg, Room 208, 10 West 32nd Street, Applied Math Department, Chicago, IL 60616. *An Efficient Rescaling Algorithm for Simulating the Evolution of Multiple Elastically Stressed Precipitates.*

In this talk, we propose a space-time rescaling scheme for computing the long time evolution of multiple precipitates in an elastically stressed medium. The scheme is motivated by a recent paper (Li, Lowengrub and Leo, J. Comput. Phys., 335 (2007), 554) for a single particle case. The algorithm is second order accurate in time,

spectrally accurate in space and enables one to simulate the long time evolution of precipitates. Our results show that without elasticity there are successive tip splitting phenomena accompanied by the formation of narrow channels between the precipitates. In presence of applied elastic field, the precipitates form dendrite-like structures with the primary arms aligned in the principal directions of the elastic field. We demonstrate that when the far-field flux decreases with the effective radius of the system, tip-splitting and dendrite formation can be suppressed, as in the one particle case. Depending on the initial position of the precipitates, we further observe that some precipitates grow while others may shrink, even when a positive far field flux is applied. (Received March 01, 2013)

76 ► *Fluid mechanics*

1090-76-84 **Akif Ibragimov*** (akif.ibragimov@ttu.edu), **Eugenio Aulisa** and **Lidia Bloshanskaya**. *Mathematical modeling and analysis of the Forchheimer flows in porous media and application.*

In this talk we will present a model for Forchheimer flow in porous media for compressible fluid. The original problem will be modeled in terms of non-linear parabolic equation of the p-Laplacian type for the pressure function only. Major difference from p-Laplacian equation is that equation degenerates only when gradient of the pressure converges to infinity. We study a time dependent functional, the diffusive capacity, defined on the solution of this equation. We proved that the diffusive capacity is very similar to so called productivity index and therefore all the obtained results have a clear physical interpretation. (Received February 18, 2013)

1090-76-87 **Thomas I Vogel*** (tvogel@math.tamu.edu). *Liquid bridges between balls: the small volume instability.*

Stability for a liquid bridge between two solid balls is studied by cutting and scaling pieces of a standardized family of Delaunay surfaces. This theoretical framework is used to analyze the problem numerically. (Received February 19, 2013)

1090-76-177 **Thomas Rey*** (treyc@cscamm.umd.edu), The University of Maryland, CSCAMM, 4146 CSIC Building, Paint Branch Drive, College Park, MD 20740. *Hydrodynamic Limit of the Granular Gases Equation*. Preliminary report.

We will present a work concerning the quasi-elastic hydrodynamic limit of the diffusively excited granular gases equation. The granular gases equation is a Boltzmann-like kinetic equation arising when one wants to give a statistical description of a rarefied gas composed of macroscopic particles, interacting via energy-dissipative binary collisions (pollen flow in a fluid, or planetary rings for example). The purpose of the hydrodynamic limit is to give a reduced description of this equation, using a fluid approximation.

As a first step to prove mathematically the validity of the quasi-elastic hydrodynamic limit of this equation, we will present results inspired from the seminal paper of Ellis and Pinsky about the spectrum of the linearized collision operator. The main differences in our case concern the lack of energy conservation and the use of an exponentially weighted Banach L^1 setting instead of the classical Hilbertian L^2 one with Gaussian weights. We will give a precise localization of the spectrum, and an expansion of the branches of eigenvalues of this operator, for small Fourier (in space) frequencies and small inelasticity, allowing to explain some of the classical features of this equation and its hydrodynamic limit, such as the clustering instability. (Received February 28, 2013)

1090-76-252 **Shankar Subramaniam*** (shankar@iastate.edu), 2080 HM Black Engineering Building, Department of Mechanical Engineering, Iowa State University, Ames, IA 50011. *Kinetic theory of gas-solid flow based on microscale simulation: a route towards describing multiscale phenomena.*

The motion of solid particles in a gas is described using the theory of stochastic point processes resulting in a hierarchy of multiparticle descriptions that culminates in the Boltzmann-Enskog (BE) equation for gas-solid flow at the one-particle level. In addition to the collision integral term encountered in the BE equation for molecular and granular gases, the BE equation for gas-solid flow contains a conditional acceleration term that expresses the dependence of particle acceleration on its velocity through forces arising from relative motion with respect to the ambient gas. Based on numerical simulation data we develop a Langevin model for particle acceleration that corresponds to a Fokker-Planck kinetic equation for gas-solid flow. Transport coefficients corresponding to particle-phase hydrodynamics are computed from this kinetic equation. We show that multiscale phenomena such as mesoscale clustering of particles can be described by the two-particle kinetic equation from the hierarchy. (Received March 03, 2013)

- 1090-76-363 **Gerardo Hernandez-Duenas*** (hernande@math.wisc.edu), 480 Lincoln Dr, Madison, WI 53706-1325, **Leslie M Smith** (lsmith@math.wisc.edu), 480 Lincoln Dr, Madison, WI 53706-1325, and **Samuel N Stechmann** (stechmann@math.wisc.edu), 480 Lincoln Dr, Madison, WI 53706-1325. *Dissection of Boussinesq non-linear interactions using intermediate models*. Preliminary report.

It is well known that the Quasi-geostrophic equations can be derived from the Boussinesq system in a non-perturbative way by ignoring waves and considering vortical modes only. One qualitative difference between those two models is the lack of skewness in the QG dynamics. In this talk, non-perturbative intermediate models that include more and more non-linear interactions will be used to identify their role in different qualitative properties of the Boussinesq system. Numerical results will be shown to describe the effect of each non-linear interaction in the transfer of energy between vortical modes and waves in each direction, transfer of energy (or the lack of it) between scales, formation of vortices and skewness. (Received March 04, 2013)

- 1090-76-439 **Saulo Orizaga***, sorizaga@iastate.edu, **Lisheng Hou**, hou@math.iastate.edu, and **Daniel N Riahi**, driahi@utpa.edu. *Resonant instability and nonlinear wave interactions in electrically forced jets*. Preliminary report.

We investigate the problem of linear spatial instability of the modes that satisfy the dyad resonance conditions and the associated nonlinear wave interactions in jets driven by either a constant or a variable external electric field. A mathematical model based on the governing equations of electro-hydrodynamics, which is developed and used for the spatially growing modes with resonance and their nonlinear wave interactions in electrically driven jet flows, leads to equations for the unknown amplitudes of such waves. These equations are solved for both water-glycerol mixture and glycerol jet cases, and the expressions for the dependent variables of the corresponding modes are determined. The results of the generated data for these dependent variables versus spatial direction indicate, in particular, that the instability that is generated by the nonlinear wave interactions of such modes is mostly of amplifying effect. The energy exchanged during the interaction is very strong and for most cases the domain of the dependent variables was significantly reduced. The amplified instability was also found to provide a significant reduction in the jet radius, which is a favorable result for practical applications (Received March 06, 2013)

78 ► Optics, electromagnetic theory

- 1090-78-250 **Gang Bao** (bao@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824, and **Peijun Li*** (lipeijun@math.purdue.edu), Department of Mathematics, Purdue University, West Lafayette, IN 47907. *Inverse Surface Scattering in Near-Field Imaging*.

This talk is concerned with an inverse surface scattering problem in near-field optical imaging, which is to reconstruct the scattering surface with a resolution beyond the diffraction limit. The surface is assumed to be a small and smooth deformation of a plane surface. Based on a transformed field expansion, the boundary value problem with complex scattering surface is converted into a successive sequence of a two-point boundary value problems in the frequency domain, where an analytic solution for the direct scattering problem is derived from the method of integrated solution. By neglecting the high order terms in the asymptotic expansion, the nonlinear inverse problem is linearized and an explicit inversion formula is obtained. The method works for sound soft, sound hard, and impedance surfaces, and requires only a single illumination at a fixed frequency and is realized efficiently by the fast Fourier transform. Numerical results show that the method is simple, stable, and effective to reconstruct scattering surfaces with subwavelength resolution. (Received March 03, 2013)

- 1090-78-256 **Peijun Li*** (lipeijun@math.purdue.edu), Department of Mathematics, Purdue University, West Lafayette, IN 47907. *An Inverse Random Source Scattering Problem*.

This talk is concerned with an inverse random source 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. Since the source and hence the radiating field are stochastic, the inverse problem is to reconstruct the statistical structure, such as the mean and the variance, of the source function from the measured random field on the boundary point. Based on the constructed solution for the direct problem, integral equations are derived to reconstruct the mean and the variance of the source function. Numerical experiments will be presented to demonstrate the validity and effectiveness of the proposed method. (Received March 03, 2013)

81 ► *Quantum theory*

1090-81-7 **Raffaele Romano*** (rromano@iastate.edu), 490 Carver Hall, Ames, IA 50010.
Ontological models for quantum theory: some recent perspectives.

Ontological models for quantum theory represent the attempt to describe the microscopic world in more classical terms, for instance, by describing the quantum probabilities as lack of knowledge of some unaccessible parameters. The motivation for such an approach is twofold: the better understanding of the fundamental principles underlying the quantum description, and the investigation of the really non-classical features of the quantum world. This is especially relevant in view of the recent development of the quantum theories of information and computation, which suggest that quantum-based protocols could outperform the corresponding classical ones, because of the departure of quantum mechanics from classical ideas. In this talk, we discuss some recent results concerning completeness of the quantum theory, and possible deviations from it. (Received November 30, 2012)

82 ► *Statistical mechanics, structure of matter*

1090-82-222 **Jim W. Evans*** (evans@ameslab.gov), Department of Mathematics and Physics & Astro, Iowa State University, Ames, IA 50011, and **Da-Jiang Liu** (dajiang@fi.ameslab.gov), Ames Laboratory 307 Wilhelm Hall, Iowa State University, Ames, IA 50011. *From stochastic molecular-level reaction-diffusion models to conventional and generalized hydrodynamic reaction-diffusion equations.*

Surface reactions involve random adsorption at and diffusive hopping between a periodic 2D array of adsorption sites (together with reaction). A fundamental challenge is to connect this stochastic molecular-level nanoscale picture to hydrodynamic reaction-diffusion equations (RDE's) describing spatial patterns on a much larger macroscale (microns for rapid diffusion). We emphasize that a key requirement is the correct description of the diffusion tensor for multicomponent systems in these RDE's. We describe a related equation-free HMM modeling tool (HCLG) developed in [1] for these systems, now implemented for realistic models [2]. Finally, we note that for spatial patterns on shorter mesoscales, refined generalized hydrodynamic RDE's may be required.

[1] Tamaro, Sabella, Evans, J. Chem. Phys. 103 (1995) 10277

[2] Liu, Evans, Surf. Sci. 603 (2009) 1706; Prog. Surf. Sci. (2013). (Received March 01, 2013)

92 ► *Biology and other natural sciences*

1090-92-5 **Alan Veliz-Cuba***, 203 Avery Hall, Lincoln, NE. *Reverse Engineering of Regulatory Networks Using Algebraic Geometry.*

Discrete models have been used successfully in modeling biological processes such as gene regulatory networks. When certain regulation mechanisms are unknown it is important to be able to identify the best model with the available data. In this context, reverse engineering of finite dynamical systems from partial information is an important problem. In this talk we will present a framework and algorithm to reverse engineer the possible wiring diagrams of a finite dynamical system from data. The algorithm consists in using an ideal of polynomials to encode all possible wiring diagrams, and choose those that are minimal using the primary decomposition. We will also show that these results can be applied to reverse engineer continuous dynamical systems. (Received October 08, 2012)

1090-92-54 **Stephen J. Willson*** (swillson@iastate.edu), Department of Mathematics, Iowa State University, Ames, IA 50011. *Obtaining simpler phylogenetic networks from more general networks.* Preliminary report.

A phylogenetic network N is a directed graph in which each vertex corresponds to a biological species and an arc from a to b corresponds to elementary genetic change from a to b . Biologists make frequent use of phylogenetic trees, in which the directed graph is in fact a tree. Typically such trees are constructed using huge datasets of the DNA of extant species. More recently, biologists have begun to utilize networks that are not trees, especially to include events such as hybridization of species or lateral gene transfer.

The reality behind such a general phylogenetic network N can be extremely complicated. It is therefore of use to make assumptions such as that N has been simplified into a tree and then to use techniques to identify a natural tree T supported by the data. This talk concerns some other classes of networks besides trees, including "normal" networks, such that one might hope that a general network N might be simplified into a network of the

given class, for example a normal network. Of special interest will be classes of networks such that simplification preserves some aspects of the biological data. (Received February 06, 2013)

1090-92-78 **David F Fernández-Baca***, 111 Atanasoff Hall, Ames, IA 50011, and **Sudheer R Vakati** (svakati@iastate.edu), 226 Atanasoff Hall, Ames, IA 50011. *Characterizing Compatibility and Agreement of Phylogenetic Trees.*

Phylogenetic trees, also known as phylogenies, represent the evolutionary history of sets of species. Trees built from different genetic information often group subsets of species in conflicting ways, leading to the following question: Given a collection of phylogenies for partially overlapping sets of species, does there exist a single tree—a supertree—that exhibits all the evolutionary information present in the input trees? We consider two versions of this problem, both of which are NP-complete. The first, and most restrictive, is tree agreement. Here the supertree must exhibit precisely the relationships among the species in each of the input trees. The second version, known as tree compatibility, is more relaxed, allowing the supertree to exhibit finer-grained evolutionary relationships among species than those exhibited by some of the input trees. We demonstrate that testing for tree compatibility and agreement is equivalent to testing whether there exist certain kinds of cuts in a graph derived from the input trees. These results shed new light on an earlier triangulation-based characterization of compatibility due to the authors. The characterization of agreement is, to our knowledge, the first of its kind for unrooted trees. (Received February 17, 2013)

1090-92-151 **Anna B. Romanowska** and **Jonathan D.H. Smith*** (jdsmith@iastate.edu), Department of Mathematics, 396 Carver Hall, Iowa State University, Ames, IA 50011. *Abstract algebra and the logic of gene expression.*

While Boolean networks provide models that are easy to analyze, they do not give a precise description of the behavior of biological networks. Under these circumstances, a method of translation from Boolean to analytical models becomes desirable. In this talk, it is shown how certain abstract algebras, namely barycentric algebras, provide a calculus for the conversion from simplified Boolean models of gene transcription to fuzzy models that give a more realistic tracking of the molecular biology. An experimental observation with actual cells closely follows the barycentric algebra format. (Received February 27, 2013)

1090-92-163 **Vladimir Itskov*** (vladimir.itskov@math.unl.edu), Department of Mathematics, LINCOLN, NE 68588-0130, **Carina Curto** (ccurto@unl.edu), Department of Mathematics, LINCOLN, NE 68588-0130, and **Chad Giusti**, Department of Mathematics, LINCOLN, NE 68588-0130. *Encoding simplicial complexes by neural networks.*

Networks of neurons in the brain encode memories via their synaptic connections, yet the relationship between network connectivity and encoded memory patterns is still poorly understood, especially in cases where the set of patterns is highly structured. Motivated by well-studied neural codes, we tackle the problem of encoding simplicial complexes in feedforward and recurrent networks. We find surprisingly strong results using various geometric and combinatorial tools, including the inverse nerve construction and Cayley-Menger determinants. (Received February 27, 2013)

1090-92-195 **Zhijun Wu*** (zhijun@iastate.edu), Department of Mathematics, Iowa State University, Ames, IA 50011. *Distance Geometry Optimization and Applications.*

A distance geometry problem is to find the coordinates for a set of points in a metric space given the distances for the pairs of points. The distances can be dense (given for all pairs of points) or sparse (given only for a subset of all pairs of points). They can be provided with exact values or with small errors. They may be given with a set of ranges (lower and upper bounds). In any case, the points need to be determined to satisfy all the given distance constraints.

The distance geometry problem has many important applications such as protein structure determination in biology, sensor network localization in communication, and multidimensional scaling in statistical classification.

In this talk, I will give a brief review on the formulation of the distance geometry problem and its solution methods. I will then present a so-called geometric buildup method and show how it can be applied to solve a distance geometry problem efficiently and deal with various types of distance data, dense or sparse, exact or inexact, effectively. I will also show how the method can be applied to a set of distance bounds and obtain an ensemble of solutions to the problem. Some computational results on protein structure determination and sensor network localization will be demonstrated. (Received March 01, 2013)

- 1090-92-268 **Xiayi Wang, Bruce P Ayati*** (bruce-ayati@uiowa.edu), **Jason M. Graham, Prem S. Ramakrishnan** and **James A. Martin**. *The Effects of Cyclic Loading on Articular Cartilage Lesion Formation*.

We present a model of articular cartilage lesion formation under the effects of cyclic loading. This model extends and modifies the reaction-diffusion-delay model by Graham et al. for the spread of a lesion formed through a single traumatic event. Our model represents "implicitly" the effects of loading, meaning through a cyclic sink term in the equations for live cells, rather than an "explicit" mechanical term.

Our model forms the basis for computer simulations of cartilage damage relevant to questions in osteoarthritis, for example, that may not be easily answered through experimental studies. (Received March 03, 2013)

- 1090-92-294 **Megan Owen*** (megan.owen@waterloo.ca). *Statistics in Tree Space*. Preliminary report. We introduce new notions of mean and variance for a set or distribution of phylogenetic trees. These definitions of mean and variance are analogous to those for a weighted set of points in Euclidean space, but with the underlying space being the space of phylogenetic trees constructed by Billera, Holmes, and Vogtmann (2001). A property of this space (non-positive curvature) ensures there is a unique shortest path between any two trees. Furthermore, this path can be computed in polynomial time, leading to a practical algorithm for computing the mean and variance. We show some applications of these, including hypothesis testing to distinguish between different distributions of phylogenetic trees. (Received March 04, 2013)

- 1090-92-306 **Isabel K Darcy*** (idarcymath@gmail.com), **Annette Honken, Hyeyoung Moon, Robert G Scharein, Guanyu Wang** and **Danielle Washburn**. *DNA knot distance graphs*. Preliminary report.

Topoisomerases and recombinases are two classes of proteins which can knot circular DNA. Type II topoisomerases are proteins which cut one double-stranded DNA segment, allowing a second DNA segment to pass through before resealing the break. This is mathematically modeled by changing a crossing. Recombinases break two segments of DNA, exchanging the DNA ends before resealing the breaks. This action can be mathematically modeled by smoothing a crossing. Distances between knots have been defined based upon the minimum number of times these proteins must act to convert one knot into another knot. A graph is formed where vertices represent knots and an edge connects a pair of knots if and only if their distance is one. Methods for calculating these distances will be discussed. Applications and ways to visualize these distances via KnotPlot will also be discussed. (Received March 04, 2013)

- 1090-92-315 **Carina Curto*** (ccurto2@math.unl.edu), 203 Avery Hall, University of Nebraska-Lincoln, Lincoln, NE 68588. *The neural ring: an algebraic tool for analyzing neural codes*.

Neurons in the brain represent stimuli via neural codes. An important problem confronted by the brain is to infer properties of represented stimulus spaces using only the intrinsic structure of neural codes. How does the brain do this? To address this question we define the neural ring, an algebraic object that encodes the full combinatorial data of a neural code, and show how it can be used to extract relevant features from the code. (Received March 04, 2013)

- 1090-92-333 **Sanjeevi Sivasankar*** (sivasank@iastate.edu), Department of Physics and Astronomy, Iowa State University, Ames, IA 50011, and **Kristine Manibog, Sabyasachi Rakshit** and **Hui Li**. *Tuning the kinetics of cell-cell adhesion*.

Cadherins are a family of cell-surface proteins that bind cells together in all soft tissue. Cell-cell adhesion is a dynamic process; cadherins tailor their binding in response to changes in the mechanical properties of their surrounding environment. However the kinetics of cadherin interactions in the presence of mechanical stress has not yet been measured. Here we use single molecule force measurements with an Atomic Force Microscope (AFM) and Molecular Dynamics simulations to identify how cadherins tune their unbinding kinetics and withstand mechanical stress. We show that cadherins form three types of adhesive bonds: catch bonds which, counter-intuitively, become longer lived and lock in the presence of tensile force, slip bonds which become shorter lived when pulled and ideal bonds that are insensitive to tugging. Catch, slip and ideal bonds allow cadherins to withstand tensile force and tune the mechanical properties of adhesive junctions. (Received March 04, 2013)

- 1090-92-337 **Hye-Won Kang*** (kang.235@mbi.osu.edu), 1735 Neil Ave, 381 Jennings Hall, Columbus, OH 43210. *Multiscale approximations in stochastic biochemical networks*.

Stochastic effects may play an important role in mathematical modeling of biological and chemical processes in case the copy number of some component involved in the system is small. In this talk, stochastic modeling

of biochemical networks with several examples is introduced and multiscale approximations of stochastic biochemical networks are suggested. Evolution of the network is modeled in terms of a continuous-time Markov jump process. Chemical reaction networks are generally large in size and they involve various scales in species numbers and reaction rate constants. The multiscale approximation method is introduced to reduce the network complexity and to derive limiting models with simple structure. Then, asymptotic behavior of the error between the full model and the limiting model is approximated. This is a joint work with Thomas G. Kurtz and Lea Popovic. (Received March 04, 2013)

1090-92-341 **Harsh Jain*** (hjain@fsu.edu), Department of Mathematics, Florida State University, 1017 Academic Way, 208 Love Building, Tallahassee, FL 32306, and **Alan Richardson** and **Helen Byrne**. *A delay differential equation model of combination chemotherapy targeting ovarian cancers.*

In this talk, we will present a delayed partial differential equation (PDE) model of solid tumor growth and treatment. The model accounts for cell cycle arrest and cell death induced by chemotherapy, and explicitly includes intracellular signaling pathways relevant to drug action. The model is simplified to give a 1D hyperbolic PDE, which is further reduced to a nonlinear, non-autonomous DDE by projecting along characteristics. Necessary and sufficient conditions for the global stability of the cancer-free equilibrium are derived and conditions under which the system evolves to periodic solutions are determined. This has clinical implications since it leads to a lower bound for the amount of therapy required to affect a cure. Finally, we will present a clinical application of the model, by applying it to the treatment of ovarian cancers. Two types of drugs are considered – platinum-based chemotherapeutic agents that are the current standard of care for most solid tumors, and small molecule cell death inducers that are currently under development. The model is calibrated versus in vitro experimental results, and is then used to predict optimal doses and administration time scheduling for the treatment of a tumor growing in vivo. (Received March 04, 2013)

1090-92-351 **Badal Joshi***, joshi@umn.edu. *Switching in biological networks.*

(Bio)chemical reaction networks are used in systems biology to model gene regulatory, protein, metabolic, and other cellular networks. Since existence of multiple steady states (MSS) provides the underpinnings for switching in chemical reaction networks, it is a fundamental problem to determine which network structures permit MSS. There exist several criteria which, when satisfied, establish that a network does not permit MSS regardless of the parameter values. On the other hand, results that establish that a network does permit MSS are rare. I will describe our recent work which provides a novel approach towards solving this problem. We show that for a large class of networks, there exists the notion of an ‘embedding’ of a smaller network into the full network and the steady states of the smaller network can be lifted to the full network. In the second part of the talk, I will describe a stochastic switch in a neuronal network which models sleep and wake states. (Received March 04, 2013)

1090-92-378 **Elena S Dimitrova, Qijun He** and **Matthew Macauley***, O-325 Martin Hall, Clemson, SC 29634-0975. *On the canalyzing depth of a Boolean function.* Preliminary report.

An n -variable Boolean function is canalyzing if some variable has the property that taking a specified input value completely determines the output. If this canalyzing variable does not take that particular input value, then the output is determined by a function on $n - 1$ variables. We may ask if it too is canalyzing, and so on. The canalyzing depth of a function measures how many steps we can recursively pick off canalyzing variables in this manner. Canalyzing functions arise naturally in models of biological systems. The special case of functions of depth n are precisely the nested canalyzing functions, and these form a toric variety. Functions of depth $d < n$ are said to be partially nested canalyzing. I will discuss some current research on the algebraic properties of these functions, and a project to reverse engineer a biological network using this class of functions. (Received March 05, 2013)

1090-92-404 **Jay M Newby***, Mathematical Bioscience Institute, Columbus, OH 43210. *Isolating intrinsic noise sources in a stochastic genetic switch.*

The stochastic mutual repressor model is analysed using perturbation methods. This simple model of a gene circuit consists of two genes and three promotor states. Either of the two protein products can dimerize, forming a repressor molecule that binds to the promotor of the other gene. When the repressor is bound to a promotor, the corresponding gene is not transcribed and no protein is produced. Either one of the promotors can be repressed at any given time or both can be unrepressed, leaving three possible promotor states. This model is analysed in its bistable regime in which the deterministic limit exhibits two stable fixed points and an unstable saddle, and the case of small noise is considered. On small time scales, the stochastic process fluctuates near

one of the stable fixed points, and on large time scales, a metastable transition can occur, where fluctuations drive the system past the unstable saddle to the other stable fixed point. To explore how different intrinsic noise sources affect these transitions, fluctuations in protein production and degradation are eliminated, leaving promoter noise as the only noise source in the system. It is found that some significant differences in the random process emerge when the noise source is removed. (Received March 05, 2013)

1090-92-417 **Brandilyn Stigler*** (bstigler@smu.edu), 3200 Dyer Street, 209-C Clements Hall, Dallas, TX 75275. *The Power of Two: The Impact of Combining Methods in Reverse Engineering Gene Networks.*

One of the central problems in molecular systems biology is the reverse engineering of gene regulatory networks from experimental data. While the number of reverse engineering methods has steadily grown in the last two decades, a persistent issue is that most methods do not perform significantly better than random guesses. Recently it has been observed that pipeline methods, that is methods used in series, significantly improves the predictive power of the reverse-engineered model. In this talk we will highlight some successful case studies specifically involving discrete methods, as well as discuss some questions that arise from building pipeline models. (Received March 05, 2013)

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1090-93-13 **Rajeev Rajaram***, 3300 Lake Rd West, Ashtabula, OH 44004, and **Umesh Vaidya**. *Almost everywhere uniform stability of an autonomous ODE.*

We consider an autonomous ordinary differential equation of the form $\dot{x} = f(x); x(0) = x_0$ on a compact set X with an invariant attractor set Λ . Almost everywhere uniform (*a.e.u.*) stability means that the Lebesgue measure of the set of initial conditions that do not eventually end up in Λ is zero, in addition to a certain integrability condition being satisfied. Recently, this concept has been used to develop the idea of controllability and observability gramians for the advection PDE, prove robustness of *a.e.u.* stability to additive perturbations, and to develop algorithms for optimal placement of actuators and sensors for the advection PDE.

This talk will present the idea of *a.e.u.* stability and several results related to the concept. (Received December 09, 2012)

1090-93-42 **Michael Malisoff*** (malisoff@lsu.edu), Department of Mathematics, 303 Lockett Hall, Louisiana State University, Baton Rouge, LA 70803-4918. *Asymptotic Stabilization for Feedforward Systems with Delayed Feedbacks.*

We study a problem of state feedback stabilization of time-varying feedforward systems with a pointwise delay in the input. Our approach relies on a time-varying change of coordinates and Lyapunov-Krasovskii functionals. Our result applies for any given constant delay, and provides uniformly globally asymptotically stabilizing controllers of arbitrarily small amplitude. The closed-loop systems enjoy input-to-state stability properties with respect to additive uncertainty on the controllers. We illustrate our work using a tracking problem for a model for high level formation flight of unmanned air vehicles. This is joint work with Frederic Mazenc from Laboratoire des Signaux et Systemes in France. (Received January 25, 2013)

1090-93-80 **Katherine A. Kime*** (kimek@unl.edu). *Explicit Approximations of Bilinear Controls using Interpolation.* Preliminary report.

We solve for controls in a discretization of a bilinear control problem for the Schrodinger equation. This involves solving systems of nonlinear algebraic equations in which both the discrete controls and the discrete intermediate states appear as variables, with initial and terminal data specified. Allowing the intermediate states to vary leads to successful solution by computer algebra. We then discuss possible interpolations of these controls to approximate the PDE control system. (Received February 18, 2013)

1090-93-120 **Ozkan Ozer*** (aozer@uwaterloo.ca), 200 University Ave W, University of Waterloo, Waterloo, Ontario N2L3G1, Canada. *Stabilization of voltage-actuated piezoelectric beams with magnetic effects.*

It is well-known that magnetic energy of the piezoelectric beam is relatively small, and it does not change the overall dynamics. Therefore, classical PDE models (relying on electrostatic or quasi-static approaches) completely ignore the magnetic energy stored/produced in the beam. These classical models are known to be exactly observable and exponentially stabilizable in the energy space.

In this talk, we briefly mention about the variational approach to derive the boundary value problem which models a single piezoelectric beam with magnetic effects. We show that the system can not be exactly observable

/ exponentially stabilizable in the energy space. We use Diophantine's approximations to give explicit polynomial decay estimates which are valid only for more regular initial data. (Received February 24, 2013)

1090-93-266 **Scott Hansen*** (shansen@iastate.edu), Department of Mathematics, Iowa State University, Ames, IA 50011, and **Jose de Jesus Martinez**, Department of Mathematics, Iowa State University, Ames, IA 50011. *Exact null-controllability of heat equation with singular specific heat*. Preliminary report.

Abstract: First we describe a possible model for heat flow between two chambers divided by a thin wall that acts as thermal barrier between the two chambers. In the idealized one-dimensional model, two heat equations on respective domains $(-a, 0)$ and $(0, b)$ are coupled through a differential equation that describes the temperature of the thermal barrier at $x = 0$. For this system, we show that by controlling the temperature at one end, for any $T > 0$, any initial state can be controlled to the zero temperature state in time T . Our approach is based on the moment method. (Received March 03, 2013)

1090-93-419 **Marisa C Eisenberg*** (marisae@umich.edu). *Identifiability & Parameter Estimation for Modeling Human Disease*.

Connecting models with data to yield predictive results requires a variety of parameter estimation, identifiability, and uncertainty quantification techniques. Identifiability analysis addresses the question of whether it is possible to uniquely recover the model parameters from a given set of data. In this talk, I will discuss my recent work developing identifiability methods using tools from computational algebra and systems theory, and present some applications to problems in human disease, including cholera, thyroid hormone regulation, and cancer. (Received March 05, 2013)

1090-93-421 **Francesca Albertini** and **Domenico D'Alessandro*** (dmdaless@gmail.com), 440 Carver Hall, Ames, IA 50011, and **Raffaele Romano**. *Exact Lie algebraic conditions for the indirect controllability of quantum mechanical systems*.

In several schemes for the control of quantum systems, a target quantum system S is put in contact with an auxiliary system A and the active control can directly affect only A . Therefore the system S is controlled indirectly through the interaction with A . The quantum system S is said to be indirectly controllable if every unitary transformation can be performed on the state of S with this scheme. The indirect controllability of S depends on the dynamical Lie algebra characterizing the dynamics of the total system $S+A$ and on the initial state of the auxiliary system A . In this talk, we describe this characterization exactly. If the dimension of the system A is greater than or equal to 3, indirect controllability of S is equivalent to complete controllability of the total system $S+A$, i.e., every unitary transformation on $S+A$ can be obtained. If the dimension of A is equal to 2, the exact condition for indirect controllability is given in terms of a Lie algebra L which describes the evolution on the system S . We prove that indirect controllability is verified if and only if L is the full Lie algebra of skew-Hermitian matrices in appropriate dimensions. and the initial state of the auxiliary system is pure. (Received March 05, 2013)

1090-93-428 **Mary Ann Horn*** (mhorn@nsf.gov), Division of Mathematical Sciences, National Science Foundation, 4201 Wilson Blvd, Suite 1025, Arlington, VA 22230. *Mathematical Challenges Arising from the Questions of Controllability and Stabilization for Linked Elastic Structures*.

In the study of control and stabilization of dynamic elastic systems, a significant challenge is the ability to rigorously address whether linked dynamic structures can be controlled using boundary feedback alone. When a structure is composed of a number of interconnected elastic elements or is modelled by a system of coupled partial differential equations, the behavior becomes much harder to both predict and to control.

In particular, structures composed of different dimensions pose serious challenges because the energy transferred through the interfaces between components can lead to uncontrollable behavior. This talk focuses on issues that arise when attempting to control such complex systems. (Received March 05, 2013)

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0192-5857(2013)34:3;1-X

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ISSN 0192-5857

American Mathematical Society

201 Charles Street, Providence, RI 02904-2294 USA

GST No. R121892046